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Well-log analysis of the upper Colorado (Turonian to Santonian) strata of southwestern Saskatchewan.

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WELL-LOG ANALYSIS OF THE UPPER COLORADO (TURONIAN TO SANTONIAN) STRATA OF SOUTHWESTERN SASKATCHEWAN

by

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ABSTRACT

The Upper Colorado Subgroup of southwestern Saskatchewan consists of two calcareous shale units, the First and Second White-Speckled Shales (approximately equivalent to the Niobrara and Greenhorn Formations of Montana respectively) in order of increasing age, separated by an unnamed non-calcareous unit (correlative with the Carlile Formation). Each unit incorporates shaly sandstones and siltstones: the Martin Sandy Zone, the Bowdoin Sandstone, and the Phillips Sandstone (Second Specks Sandstone of southeastern Alberta), listed from youngest to oldest. In Saskatchewan, gas production from the Upper Colorado succession is currently limited to the Medicine Hat Sandstone, which is located some 30.5 m below the top of Colorado Group. The Bowdoin and Phillips sequences and chalks and shaly chalks of the Greenhorn Lime at the top of the Greenhorn Formation yield gas production in the Bowdoin dome region of Montana, as does the Second Specks Sandstone in southeastern Alberta.

The shaly sandstone bodies are composed of fine- and very fine-grained sandstones and siltstones, interbedded with bituminous shale and mudstone. They display northeasterly increase in intercalated mudstone across southwestern Saskatchewan. The Phillips Sandstone is

the only unit to exhibit systematic vertical variation in grain size, seen as upward coarsening, and undergoes a progressive decrease in thickness northeastwards, which takes the form of attenuation of successive packets of sandy strata at the base of the sequence. Fluid-flow characteristics of the sandy units which are obtained from core and geophysical well logs analyses are related to lithology, with permeabilities generally less than 1.0 md and porosities ranging from 15 to 22%, decreasing in a northeasterly direction.

Water analyses show that the most common ions are: Cl^- at up to 58.4%, Na^+ and K^+ (40.8%), and Ca^{++} (3%). The total solids concentration is relatively low, which reaches up to 36960 mg/l, is related to the shallow depth of occurrence. The presence of organic matter in the evaporated total solids suggests the biogenic origin of the gas. Gas analyses show that methane is the chief component of the natural gas, which had a shallow, low-temperature, biogenic origin. Prospects for natural gas in the area from the Upper Colorado succession are supported by the numerous showings recorded in drill stem tests and by the showings reported by the Saskatchewan Department of Mineral Resources. It is also suggested that the area to the southwest of the belt of pronounced thickness reduction and facies change in the Phillips

Sandstone is a prospective source for natural gas in the unit. The possibility of drainage of gas southwards across the international boundary and westwards across the Alberta border in the Phillips Sandstone, Greenhorn Lime, and Bowdoin Sandstone is suggested by lithologic comparison with the Medicine Hat Sandstone, penetrated by wells drilled in fractional sections along the Fourth Meridian, north of the study area.

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INTRODUCTION

Study Area

The study area is located in the southwestern corner of Saskatchewan (Fig. 1), between the Fourth Meridian and the eastern limit of Range 21W3 and between the Forty-ninth Parallel of latitude and the northern limit of Township 10.

The Problem

Production of non-associated natural gas from a number of shaly sandstone reservoirs of Upper Cretaceous age is of increasing commercial importance in and to the immediate east of the Sweetgrass Arch region of southeastern Alberta, southwestern Saskatchewan and north-central Montana. Since the discovery of natural gas in the Medicine Hat Sandstone (First White-Speckled Shale, Colorado Group) in 1904, the unit has been exploited extensively in Alberta and Saskatchewan, notably at the Medicine Hat, Hatton and Horsham production locales (Hancock and Glass, 1968). An earlier discovery of natural gas in the Medicine Hat area in 1890 was in the Milk River Formation (Montana Group), but commercial production was not obtained on a significant

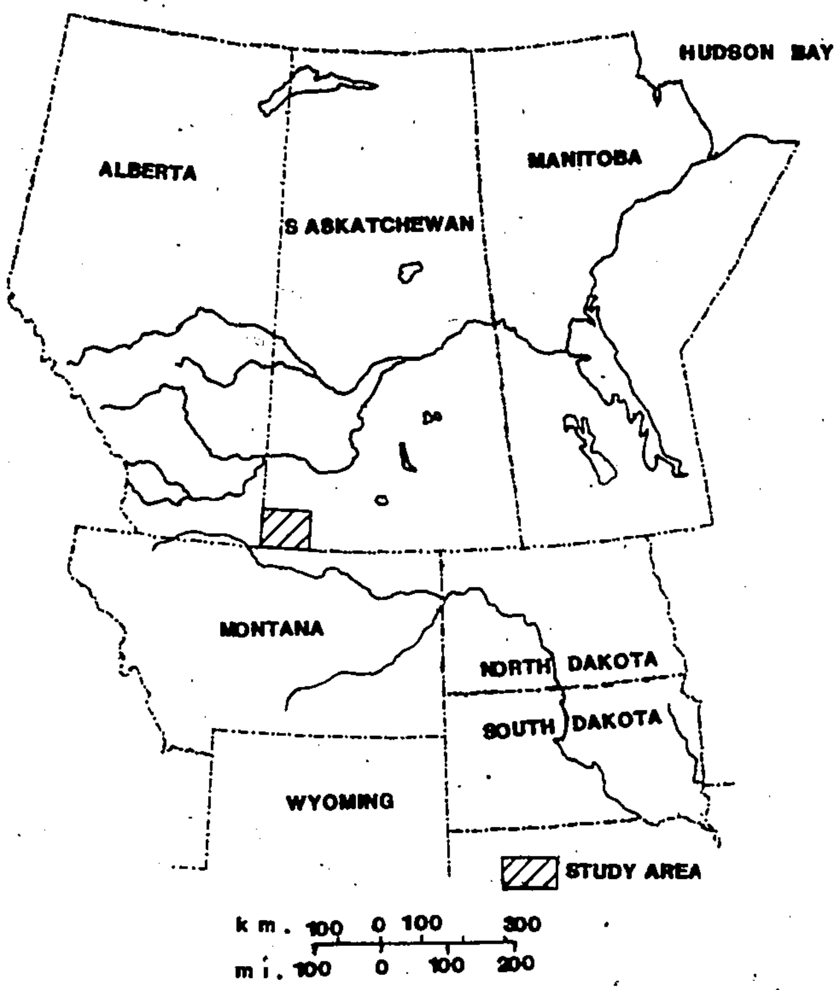

Fig. 1. Location Map.

scale until recent years, because of low reservoir pressures and difficulties in delineating pay zones in a monotonous sequence of shaly, fine-grained sandstones. Currently there is production of natural gas from the Milk River Sandstone in and around the Suffield Block of southeastern Alberta and the Hatton and Leibenthal fields of southwestern Saskatchewan. In the Bowdoin dome region of Phillips and Valley Counties in north-central Montana, the occurrence of natural gas in shaly sandstones of the upper part of Colorado Group has been known since 1913. However, exploitation of these reserves from two main sandy units, the Phillips Sandstone and overlying Bowdoin Sandstone, begun in the 1950s, was greatly expanded only in the 1970s, because of improved well-completion techniques and increased gas prices. These low-pressure, low-permeability reservoirs occur at depths of less than 2000 ft. (610 m) in the Bowdoin dome region. The Second Specks Sandstone, a sequence of shaly sandstones, roughly correlative with the Phillips Sandstone, has yielded commercial quantities of natural gas in the Suffield Block of southeastern Alberta. In Saskatchewan, production of gas from the upper part of the Colorado Group is restricted to the important Medicine Hat Sandstone production noted above; initial gas in place in the Second White-Speckled Shale of the Colorado Group in western Saskatchewan is estimated at 1289.9 million cubic meters, but so far none of this has been produced (Saskatchewan Mineral Resources, 1979).

The northern termination of the Bowdoin field of north-central Montana is where the production trend meets the Forty-ninth Parallel. At present no attempt has been made to delineate possible pay sections to the immediate north of the international boundary.

Previous Work

The general stratigraphic relationships between shaly sandstone units within the upper Colorado section of north-central Montana were outlined by Schroth (1953), who made reference to the Phillips Sandstone, the Bowdoin Sandstone, and the Martin Sandy Zone, in order of decreasing age; these are the names given to sandy developments within the marine, dominantly argillaceous Greenhorn, Carlile, and Niobrara Formations respectively (Fig. 2). Additional stratigraphic information on these units in north-central Montana has been provided by Rice (1976) and Rice and Schurr (1978, 1980). An important paper by Campen (1975) describes the results of well-log analysis of the Upper Cretaceous shaly sandstone reservoirs of north-central Montana and includes some discussion of reservoir characteristics of both the Phillips Sandstone and the Bowdoin Sandstone; reference was made to the use of electrical and

SERIES		SOUTHEASTERN ALBERTA	SOUTHWESTERN SASKATCHEWAN	NORTH-CENTRAL MONTANA
UPPER CRETACEOUS		Pakowki	Lea Park Pakowki	Pakowki
		MILK RIVER	MILK RIVER	Eagle Virgelle
				Telegraph Creek
	UPPER COLORADO	FIRST WHITE-SPECKLED SHALE (Martin Sandy Zone)	FIRST WHITE-SPECKLED SHALE (Martin Sandy Zone)	NIOBRARA FM (Martin Sandy Zone)
		SHALE	SHALE (Bowdoin Sandstone)	CARLILE SHALE (Bowdoin Sandstone)
		SECOND WHITE-SPECKLED SHALE (Second White Specks Sandstone)	SECOND WHITE-SPECKLED SHALE (Phillips Sandstone)	GREENHORN LIME
				PHILLIPS SANDSTONE
	LOWER COLORADO	SHALE	SHALE	BELLE FOURCHE SHALE
		FISH SCALE ZONE	FISH SCALE ZONE	
LOWER CRETACEOUS		SHALE	SHALE	MOWRY SHALE
		BOW ISLAND	VIKING	BOW ISLAND-NEWCASTLE

Fig. 2. Correlation chart of Upper Colorado Subgroup in north-central Montana, southwestern Saskatchewan and southeastern Alberta.

radiation logs and the computer-oriented SARABAND* technique. More recent reservoir-evaluation studies deal with the Phillips Sandstone, the overlying calcareous shales (Greenhorn Lime) and the Bowdoin Sandstone (Nydegger et al., 1979) and the Bowdoin Sandstone alone (Henry, 1979) in the Bowdoin dome area. A general account of the lithologic variation in the Colorado Group of Saskatchewan was provided by Simpson (1975), who more recently described the relationship between tectonism and sedimentation during deposition of Colorado Group in that area (Simpson, 1979a). The same author outlined the main lithologic features of the Upper Colorado shaly sandstones of southwestern Saskatchewan (Simpson, 1979b, 1979c), gave separate lithostratigraphic descriptions for each shaly sandstone unit and the enveloping shales (Simpson, in press a) and has logged all available cores of these units in the area (Simpson, in press b).

Scope of Study

The purpose of the present account is to provide a detailed analysis of the main reservoir characteristics of the Phillips Sandstone, the Greenhorn Lime, the Bowdoin Sandstone, and the Martin Sandy Zone within the study area. Data employed in the study take the form of descriptions

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*Trade mark of Schlumberger.

(modified after Simpson, in press b) of selected, cored sections, stored at the Subsurface Geological Laboratory of the Saskatchewan Department of Mineral Resources, and lithological fluid properties, derived by direct analysis and by well-log interpretation. Core and fluid analyses and suites of geophysical well logs from selected wells were supplied by the Saskatchewan Department of Mineral Resources (Table 1).

Cores were described with reference to the scheme of sequence elements devised by Simpson (1971), in which patterns of lithologic variation are related to reservoir quality, particularly with regard to the abundance of reservoir heterogeneities. Core descriptions were compared with available core analyses and were related to the suites of geophysical well-logs, run in the same wells. Electrical logs provided resistivity values and related measures of water saturation. The results of drill stem tests were related to well-log characteristics.

Acknowledgements

The present study was conducted as part of the project Low-Permeability Gas Reservoirs in Marine Cretaceous Sandstones of Saskatchewan carried out by F. Simpson at the University of Windsor. Funding of the study took the form of research grants from the Saskatchewan Geological Survey

TABLE 1. Data used to determine the main reservoir characteristics of the Upper Colorado succession in southwestern Saskatchewan.

Data	Martin Sandy Zone (Medicine Hat)	Bowdoin Sandstone	Greenhorn Lime	Phillips Sandstone
Core Description	2	1	7	9
Core Analyses	–	–	1	5
SARABAND Logs	3	2	–	2
Geophysical Well Logs	11	11	11	11
Water Analyses	5	–	–	17
Gas Analyses	1	–	–	13
Drill Stem Tests	6	–	16	29

and National Science and Engineering Research Council Operating Grant A9174, both held by Simpson.

I am most grateful to Dr. F. Simpson for suggesting this project, for his supervision of this work and, of course, for his tireless reading of this thesis in manuscript.

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Furthermore, I am grateful to the personnel of the Saskatchewan Department of Mineral Resources for their cooperation in supplying well data.

REGIONAL SETTING

General Remarks

Relationships between stratigraphy and structure in southern Saskatchewan have been described by Christopher *et al*. (1971, 1973) and Kent and Simpson (1973a). The depositional history of the entire Colorado Group of southern Saskatchewan was discussed by Simpson (1975), who related patterns of sedimentation to development of the tectonic framework in a later paper (Simpson, 1979a). The following account of general stratigraphy is largely based on this previous work.

Stratigraphy

The Colorado Group (Fig. 3) is made up of marine, clastic sediments, which interdigitate with subordinate fluvio-marine deposits in the lower part of the succession. In Saskatchewan, the top of the Mannville Group (Middle Albian) marks the lower limit of the Colorado Group, while the top is delimited by the base of the Milk River Formation and the equivalent Lea Park Formation (Santonian-Campanian) of the Montana Group.

The Colorado Group is divided into upper and lower subgroups at the base of the Second (Lower) Speckled Shale

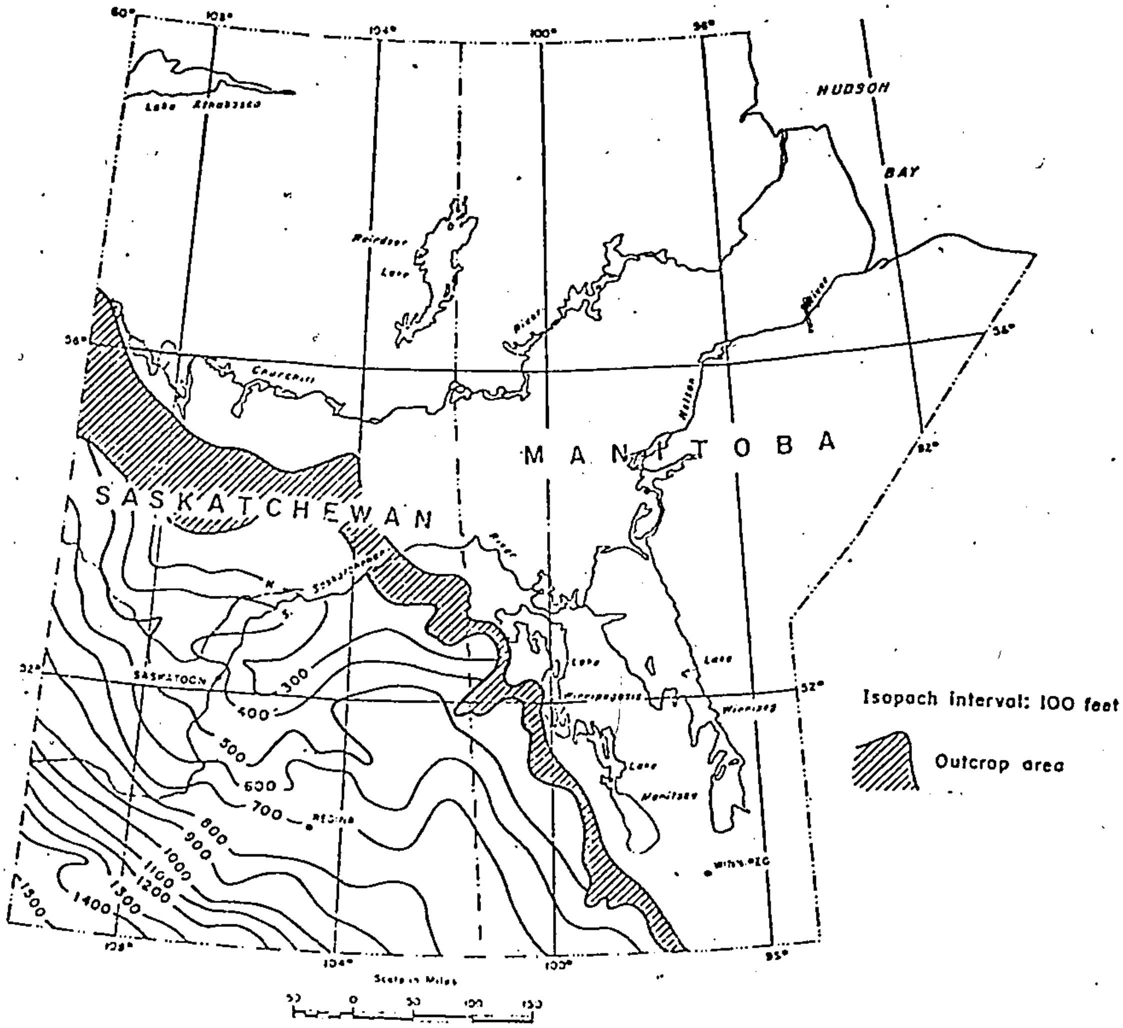


Fig. 3. Isopach map of Colorado Group, Saskatchewan and Manitoba (after Christopher et al., 1971).

(Turonian) in western and south-central Saskatchewan and the Favel Formation in eastern Saskatchewn and Manitoba. The boundary between Lower and Upper Cretaceous strata is at the base of the Fish-Scale Marker, which is 60 to 100 feet (18 to 30.5 m) below the base of the Upper Colorado Subgroup.

The clastic succession of the Colorado Group in the Rocky Mountains and Northern Great Plains can be described as a repetition of a number of generalized sequence elements (Table 2), each element is characterized by particular gross lithologies and associated sedimentary structures.

In Saskatchewan, the maximum thickness of the Upper Colorado Subgroup reaches 600 feet (183 m) of marine, argillaceous sediments. It consists of two white-flecked, grey, calcareous shale units, containing subordinate fine-grained sandstone, siltstone and argillaceous limestone and these two units are separated by a non-calcareous shale unit. In southern and western Saskatchewan, the upper calcareous unit is the First White-Speckled Shale, which reaches up to 350 feet (106.7 m), while the lower unit reaches up to 200 feet (61 m) thickness and it is named the Second White-Speckled Shale. These two units are separated by an unnamed non-calcareous unit, which reaches maximum thickness of 200 feet (61 m) and is correlated with

TABLE 2. Sequence elements, based on gross lithologic associations and layer properties, in cores of Colorado Group in Saskatchewan.

SEQUENCE ELEMENT	SUB-ELEMENT	REMARKS
Type-V conglomeratic element	(c) pebbly mudstone (b) conglomerate (a) pebbly mudstone	coarse traction load and lag concentrates of nodular and broken concretionary material
Type-IV sandstone element	(e) sandstone with dune-scale cross-lamination (d) sandstone with horizontal lamination (c) sandstone with trough cross-lamination (b) sandstone with ripple-drift cross-lamination (a) flaser-bedded sandstone	continuous mudstone layers frequently intercalated; best original porosity usually plugged by cement (siderite, calcite, pyrite
Type-III muddy sandstone-siltstone element	(c) bioturbated sandstone (b) bioturbated muddy sandstone (a) bioturbated muddy siltstone	continuity of mudstone layers mostly disrupted by biogenic reworking
Type-II siltstone-sandstone element	(d) wavey-bedded, composite layers of sandstone, siltstone and mudstone (c) wavy-bedded simple layers of sandstone, siltstone and mudstone (b) alternating mudstone and sandstone/siltstone with low-angle, planar cross-lamination (a) lenticular-bedded siltstone and sandstone in mudstone	coquinoidal layers of pelecypod and fish-skeletal debris common
Type-I mudstone element	(c) subordinate siltstone and sandstone in lenses and scarce continuous layers (b) subordinate siltstone and sandstone in flattened lenses (a) structureless mudstone	frequently incorporate coquinoidal layers, bentonitic mudstones, siderite and calcite concretions, nodular phosphorite

the Carlile Shale of the northern and central United States. In Manitoba and eastern Saskatchewan, the upper calcareous unit is the Boyne Member (Coniacian-Santonian) of the Vermilion River Formation and the non-calcareous unit is the Morden Member (Turonian-Coniacian) of that formation, while the lower calcareous unit is the Favel Formation (Turonian). In central Saskatchewan, the unnamed non-calcareous unit is missing and the White-Speckled Shales comprise up to 100 feet (30.5 m) with 20 feet (6 m) or less of the Second White-Speckled Shales (Jeletzky, 1973; North and Caldwell, 1975; Simpson, 1975). The thinning of all three shale units toward the northeast, is a result of thinning or the disappearance of the Second White-Speckled Shales and the disappearance of the non-calcareous unit in central Saskatchewan, and the appearance of younger, inclined, composite layers above surfaces of disconformity, toward the northeast, which delimit the shale marker units.

In western Saskatchewan, each of the Upper Colorado argillaceous units incorporates shaly sandstone and siltstone: the Martin Sandy Zone of the First White-Speckled Shale, the Bowdoin Sandstone of the unnamed non-calcareous shale, and the Phillips Sandstone of the Second White-Speckled Shale, in order of increasing age. The uppermost part of the Upper Colorado Subgroup, which also occupies the uppermost part of Martin

Sandy Zone, incorporates the Medicine Hat Sandstone in southwestern Saskatchewan and southeastern Alberta, 80 to 100 feet (24.4 to 30.5 m) below the top of the Colorado Group, with a maximum thickness of 13 m.

Sedimentation History

In southern Saskatchewan, the argillaceous sediments of the Colorado Group were deposited within environments developed across a shallow, epeiric sea, which was continuous over the Western Interior of Canada and the United States by Cenomanian time. The sea formed when the southward and the northward advancing, temperate and gulfian seas, merged together across western Kansas, southern Colorado, northern New Mexico and southeastern Utah, with the depositional basin near the Colorado-New Mexico line. A series of clastic wedges deposited east of the western tectonic land of Nevadan origin peripheral to the Cretaceous seaway, while minor quantities of detritus deposited in the eastern cratonic land, including the Canadian Shield and Siouxia arch of South Dakota and Nebraska. These sediments were laid down in Alberta exogeosyncline and Green River and Uinta exogeosyncline, adjacent to the Alberta-Montana belt and Wasatch hinge belt, respectively. The Wasatch hinge belt was flanked to the east by an unstable shelf which is replaced eastward by the Williston basin and southward by a series of yoked basins (Powder River, Big Horn, Denver, San Juan and others) with intervening intracratonic uplifts.

The Phillips Sandstone of the Greenhorn Formation, the Bowdoin Sandstone of the Carlile Formation, and the Martin Sandy Zone of the Niobrara Formation, were deposited in shelf depositional environments. The Phillips Sandstone and the Martin Sandy Zone were laid down during the late transgression. The non-calcareous shales were deposited during the middle Turonian regression. The Medicine Hat Sandstone consists of muddy siltstone and very fine- and fine-grained sandstone which represents a climax condition of grade on the western shelf of the Colorado sea. The top of the unit is defined by one or more calcite concretionary layers associated with thin overlying bentonite and underlying, relict fragments of concretionary siderite and fish-skeletal debris.

Structure

Three regional elements are dominated by the Precambrian basement: a homocline, a Laramide syncline, and an anticline shown in Figure 4 (Christopher *et al.*, 1971). The homocline with southerly dip, averaging between 2 and 3.7 m per kilometer and increasing to 7.4 to 9.2 m per kilometer on the northern and eastern approaches of the Williston Basin. The strike of the homocline changes from westnorthwest in Saskatchewan

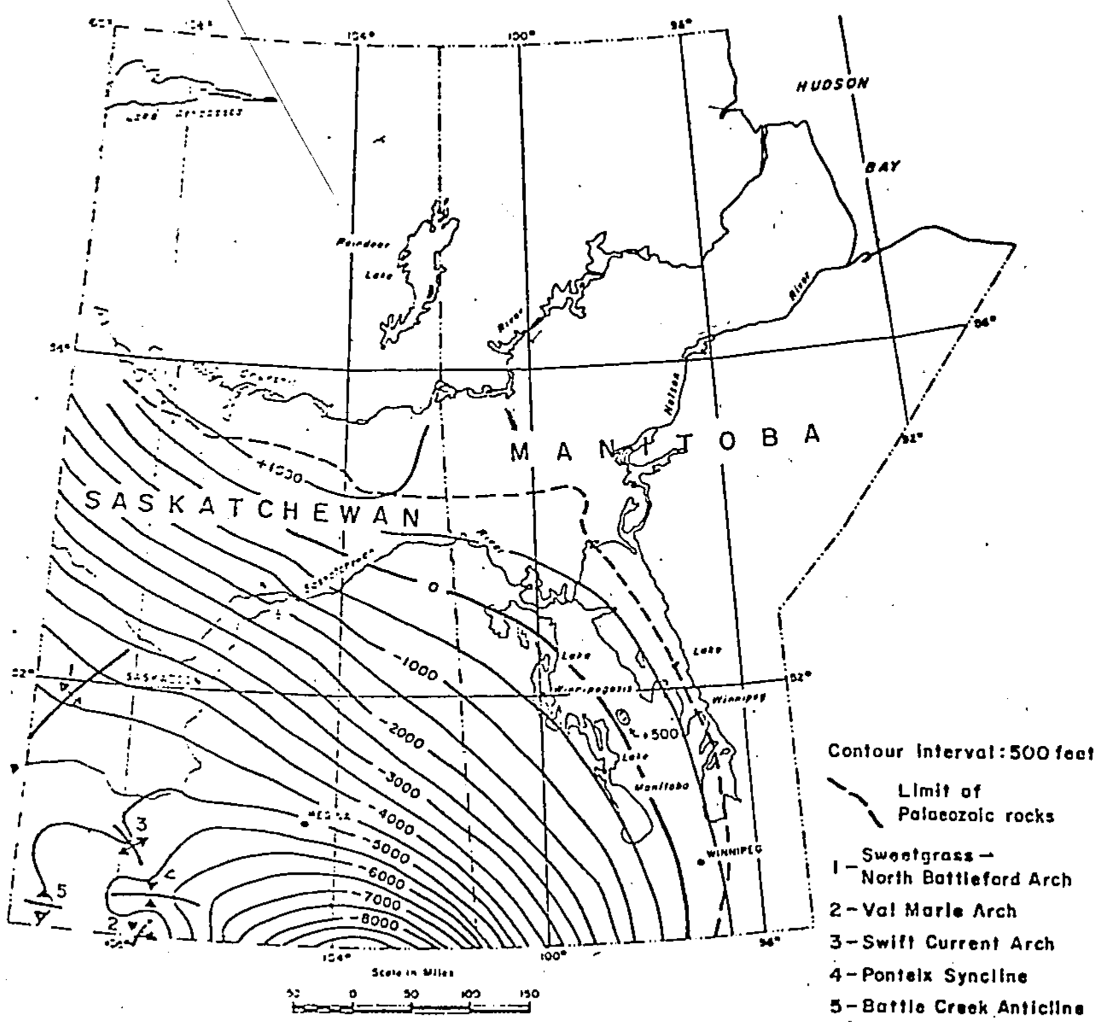


Fig. 4. Structure contour map on the Precambrian surface of Manitoba and Saskatchewan (after Christopher et al., 1971).

to north in Manitoba. The homocline flattens near Alberta to form the western flank of the Williston Basin at the ends of the Sweetgrass and North Battleford Arches which are plunging northwest- and southwards respectively. There are also some local Laramide domal features modified the region, such as the Val Marie Arch, an anticlinal nose plunging northward into the Ponteix Syncline of Saskatchewan from Bowdoin Dome of Montana, and the Swift Current Arch which is north of Ponteix Syncline. The Williston Basin was also tectonically active during the Ordovician, Silurian and Jurassic periods beside the Laramide events. The southern limit of the basin was tectonically active during other periods also, because it appears to delimit many Devonian and Mississippian formations, it formed the southeastern limit of the Elk Point Basin of the Middle Devonian time. The relatively large thickness of Mississippian strata removed by erosion near Alberta proves the existence of an ancestral Sweetgrass Arch during post-Mississippian — pre-Lower Jurassic time. The study area is located at the eastern limit of the Sweetgrass Arch.

Local and regional structures are produced because of salt removal which caused a consequent collapse of younger strata which underlained by the Middle Devonian Prairie Evaporite. In southwestern Saskatchewan, a large traingular-shaped, salt-free depression of 23,000 square miles is in to the north in Manitoba. The homocline flattens near Alberta to form the western flank of the Williston Basin at the

the area, this depression is outlined by a prominent scarp along its northeastern and northwestern sides, and this caused the draping of the younger strata over the salt.

Hydrocarbon Occurrence

Non-associated natural gas is produced from a stratigraphic-structure trap in the Upper Cretaceous Medicine Hat sand. The production is restricted to the Hatton and Horsham fields and it is located along the eastern flank of the Sweetgrass Arch. The average depth of the producing horizon is 1,565 feet (477 m) at Hatton and 1,700 feet (518 m) at the Horsham district of the Hatton field. The Medicine Hat sand occurs about 90 feet (27.4 m) below the top of Colorado Group with a thickness of up to 35 feet (10.7 m) near the Alberta border in the Hatton field. The average net effective pay is 9 feet (2.74 m). The reservoir rocks have an average porosity and permeability of 21 percent and 45 md, respectively. The connate water saturation has an average value of 50 percent. No gas-water interface is recognized, but anomalous gas-water relationships have been recorded in the belt peripheral to the southern edge of the production area. The initial bottom-hole pressure averaged 625 psia at a temperature of 62°F. The gross heating value is 946 BTU/cubic feet.

In Cypress Hills region, the Second White Specks Sandstone is one of the potential gas-producing formations along with Milk River and Upper Shaunavon Formations (Saskatchewan Department of Mineral Resources, 1977). There is no gas production from the Cypress Hills region at this time. The average depth of the horizon is 2770 feet (844 m) in Saskatchewan and 2010 feet (612.6 m) in Alberta. The Second White Specks sandstone occurs some 500 feet (152 m) below the top of the Colorado Group. The net effective pay is about 10 feet (3 m). The average porosity of the reservoir rocks is 22 to 23 percent and the average percentage of the connate water saturation is 40. The initial bottom-hole pressure is about 940 psia at a temperature of 85°F in Saskatchewan and 830 psia at a temperature of 80°F in Alberta. The gross heating value is 960 and 970 BTU/cubic feet in Saskatchewan and Alberta, respectively.

In the Bowdoin Dome area of north-central Montana, the main trapping mechanisms of the natural gas in the Upper Colorado sandstones are stratigraphic and structural traps. The natural gas in the Upper Colorado sandstones is also trapped in structural-stratigraphic traps in the Medicine Hat Sandstone pools (Alderson, Atlee/Buffalo, Jenner and Princess) of southeastern Alberta.

In southwestern Saskatchewan, the hydrocarbons in the Viking Formation of Lower Colorado Subgroup are trapped in structural-stratigraphic traps. Also, the Milk River Formation natural gas is trapped in structural-stratigraphic traps in the Hatton and Liebenthal Pools of southwestern Saskatchewan.

LITHOLOGIES AND FLUID-FLOW CHARACTERISTICS

General Remarks

The account of lithology of the Upper Colorado succession is based on the description of nine selected cored sections (Appendix 1).

The shaly sandstone and siltstone bodies of Upper Colorado Subgroup in southwestern Saskatchewan are correlated with the equivalent gas-bearing strata in southeastern Alberta and the Bowdoin dome region of north-central Montana. These correlations are shown in Figures 6 through 15. The correlation surfaces were based on the responses of spontaneous potential (SP) and resistivity logs run for the Upper Colorado succession and integrated with core studies. The SP log distinguishes between the permeable and non-permeable beds, and can locate the boundaries between such beds. Opposite the shales, the SP curve usually follows a straight line. This line is called the shale base line. Opposite permeable formations, the SP curve shows departure from the shale base line. The deflection may be either to the left (negative) or to the right (positive), depending mostly on the relative salinities of the formation-fluids and the drilling fluids:

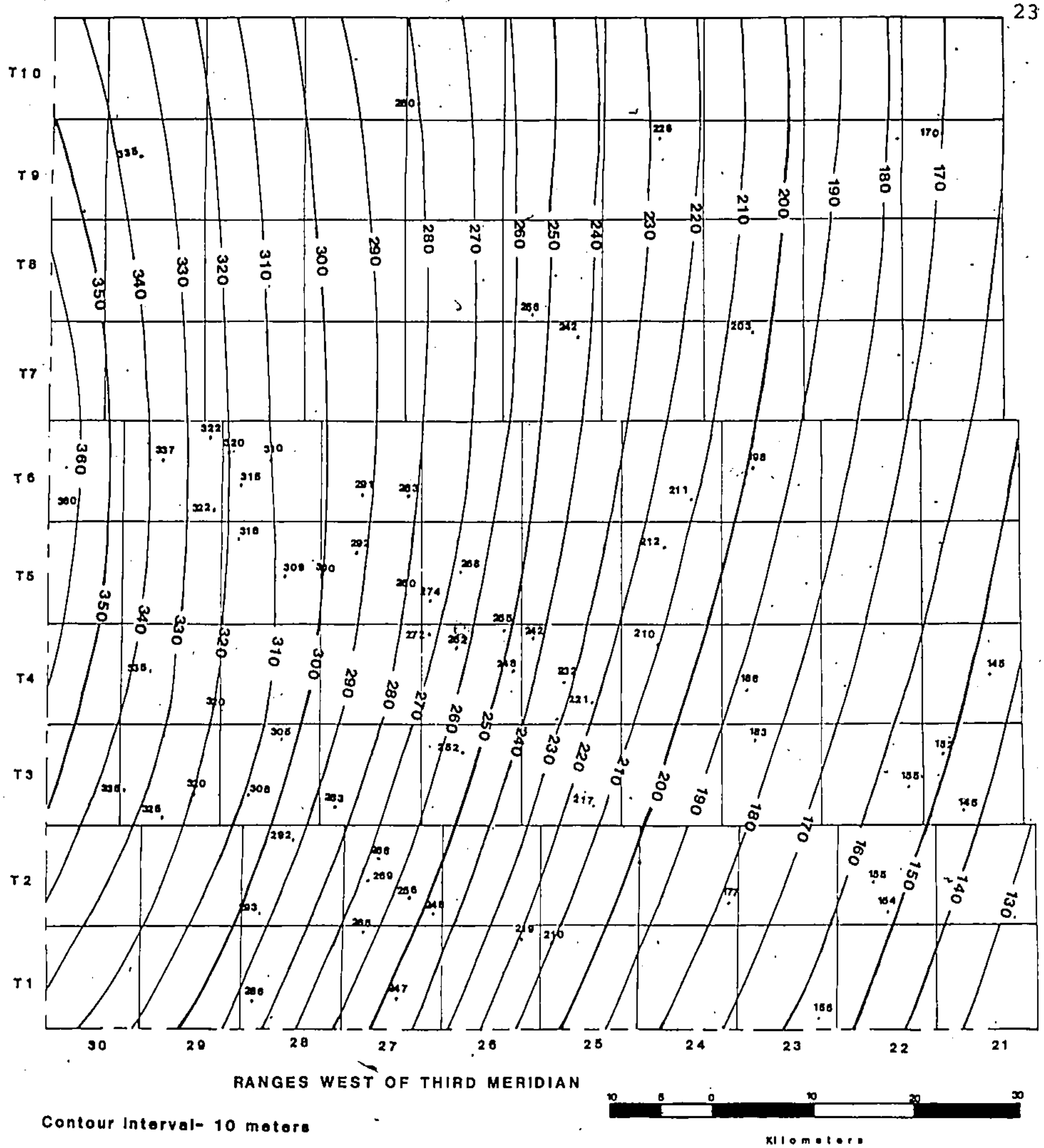
when the drilling fluid salinity is less than the salinity of the formation-fluids, the deflection is positive. Furthermore, if the resistivities of the mud filtrate and formation water are very close, the SP deflections will be small and the curve will be featureless (Stratton and Ford, 1950).

The resistivity log can be used to determine the boundaries of resisted formations, and it presents the possibility for detection of thin beds by using the induction-type. The resistivity log shows lower values across permeable formations (Stratton and Ford, 1950).

Figure 5 shows structure contours on the top of the Upper Colorado Subgroup in the study are, where the sea level is considered to be the structural datum. The topography on the surface of the Upper Colorado Subgroup shows that the general slope is west-east. The Shaunavon monocline has an easterly direction dip which is similar to the general trend of the contours in the study area.

The fluid-flow characteristics were obtained from core analysis, SARABAND logs, and geophysical well-logs. These results are presented in Appendices II, III, and IV. The porosity, permeability and water saturation were obtained from core analyses and compared with the values obtained from the geophysical well-logs.

The amount of shale in the sand has great effect on



STRUCTURE CONTOUR MAP FOR
THE TOP OF UPPER COLORADO SUBGROUP
IN SOUTHWESTERN SASKATCHEWAN

Figure- 5

responses seen on the well-logs, and shows very high porosity with respect to the results obtained from core analysis and SARABAND logs. Intensive bioturbation generally affects a decrease in reservoir quality by reducing effective permeability and porosity (Boethling, 1977, p. 173). But it has a reverse effect at the mesoscopic scale, when the bioturbation has destroyed the continuity of the reservoir heterogenetics, by increasing the effective permeability and porosity.

In evaluating the Suffield Block of southeastern Alberta, resistivity was used for mapping the gas potential of the productive Second White Specks, Medicine Hat, and Milk River units (Rice and Shurr, 1978). A 10 ohm-meters cutoff was established for resistivity values extrapolated into the Suffield area from older wells using 16 inch normal curve. When uniform logs were available throughout the area, a 12 ohm-meters cutoff was used on the spherically focused induction log. In this type of evaluation, some important observations should be made. First, the resistivity cutoffs represent present-day economic limits. Potential tight reservoirs in the siltstone and shale facies very likely fall below this cutoff. Second, resistivity determinations are good only for a small area where the uniformity logs can be maintained and the result can be calibrated to core and production test data. Finally, the resistivity values can only be used to calculate "relative" net pay because many of the beds are less than 305 mm thick and are averaged out over a 2 m interval (Rice and Shurr, 1978, pp. 277, 278).

The Upper Colorado Subgroup of southwestern Saskatchewan is characterized by a progressive northeasterly increase of intercalated mudstone in all units and attenuation of the lowermost sandy strata of the Phillips Sandstone (Figs. 12 and 13). The increase of mudstone affected the porosity and permeability of the units by reducing their values in a northeasterly direction.

The porosities of the shaly sandstone and siltstone bodies has an average mostly range from 15 to 22 percent, while the permeabilities are relatively low, with values mostly less than 1.0 md. Campen (1975) used different methods to calculate the porosities and permeabilities of the sandstone bodies. His work is based on calculating the porosity from neutron and density logs, and plotting them versus the reading of gamma ray log. Also his results are based on the interpretation of SARABAND logs. Henry (1979) has studied the shaly Bowdoin Formation of northern Montana by comparing the porosity values from sonic and neutron logs for gas detection, and sonic-density comparisons for determining the shale content.

Martin Sandy Zone

The correlation between the Martin Sandy Zone of southwestern Saskatchewan, southeastern Alberta and north-central Montana is presented in Figures 6 through 15. The Martin Sandy Zone is the only sandy unit along with the Second White Specks Sandstone in southeastern Alberta (Figs. 7, 8 and 9). Figure 16 is the isopach map for the unit in the study area, and it shows that the unit reaches a maximum thickness of more than 80 m.

The Martin Sandy Zone of north-central Montana, southeastern Alberta and southwestern Saskatchewan consists of muddy siltstone interbedded with fine- and very fine-grained sandstones. It also contains silty, calcareous, speckled mudstone. The sandstones are medium grey (N5) to light olive grey (5Y6/1), quartzose, micaceous, in lenses and continuous layers up to 2 cm thick, with horizontal and gently inclined laminations, and is occurring as type-II elements. The siltstone is medium dark grey (N5) and is dark grey (N3) when it is muddy. Mud occurs in stringers and layers up to 1 cm thick. Scattered pelecypod and fine fish-skeletal debris are seen within the sandstone.

The Medicine Hat Sandstone is the principal sandstone unit of the Martin Sandy Zone. The unit reaches up to 14 m in thickness in southeastern Alberta and southwestern Saskatchewan, and shows northeasterly thinning (Figs. 7, 8 and 9). In Figure 10, the unit maintains a constant thickness before shaling out between the AEG Buttes Horsham 7-26-17-27 well (Lsd 7-26-17-27W3) and Fox Valley No. 13-11 well (Lsd 13-11-19-26W3). In the Suffield Block area, the Medicine Hat Sandstone is divided into units A and B by the Suffield Evaluation Committee (1974, Map B). The top of the Martin Sandy Zone appears to be equivalent to the Medicine Hat A (Fig. 10).

The Medicine Hat Sandstone consists of muddy siltstone and fine- and very fine-grained sandstone. The siltstone is calcareous, speckled and occurs in lenses and continuous layers up to a few cm thick, with intercalations of speckled mudstone. The proportion of siltstone increases downward accompanied by an increase in mud content. The sandstone is quartzose, calcareous, micaceous. It occurs in type-II elements which coaresening upward into type-III elements. The sandstone is extensively bioturbated, and it incorporates pelecypod debris and fish-skeletal materials. The sandstone is cross-laminated and horizontally laminated layers. The top of the unit is marked by one or more calcite concretionary layers, with cone-in-cone calcite crystals, immediately below several bentonite layers (Kendall and Simpson, 1974). The calcite layers form a cap for the Medicine Hat Sandstone in the Hatton and Horsham fields of southwestern Saskatchewan.

The porosity of the Martin Sandy Zone was obtained from geophysical well logs (sonic and density logs) and SARABAND logs (Appendices III, IV). The values obtained from the SARABAND logs are relatively low, with 4 percent as a minimum value and 26 percent as a maximum value with an average of 14 percent (Table 3). The maximum values occur at the top of the unit and decrease downward (Fig. 19). The upward increasing in porosity is related to the coarsening upward in the lithology of the unit. Table 4 shows the highest average values occur in the western ranges of the study area (Ranges 28, 29 and 30W3) and decrease towards the east (Range 24W3). Also, it shows that the porosity decreases towards the south with an average value of 12.7 percent at CDN RES HB Arena 7-35-1-26 well (Lsd 7-35-1-26W3), and an average value of 23.4 and 22.9 percent at SPC Shell Maple Creek 6-21-9-26 well (Lsd 6-21-9-26W3) and at SPC Shell Maple Creek 7-6-10-26 well (Lsd 7-6-10-26W3), respectively.

Permeabilities were obtained from SARABAND logs and are related to the upward coarsening of the lithologies, with the highest values at the top of the unit (Appendix III). The average value is 8.1 md with values of 0.1 md are largely common.

Water saturation was calculated from SARABAND and well logs (Appendices III and IV). The values estimated from the SARABAND logs range between 48 and 100 percent with an average of 76 percent, whereas those calculated from the analysis of well logs range between 50 and 100 percent with

TABLE 3. Summary of the porosity, permeability, and water saturation obtained from SARABAND logs for the Martin Sandy Zone.

	POROSITY %		PERM. (md)		WATER SAT. %	
	Range	Average	Range	Average	Range	Average
7-34-3-28W3	9.8-24.3	15.7	0.1-80.0	7.24	50-100	64.16
10-3-3-29W3	4.0-22.0	11.6	-	-	76-100	95.30
7-21-9-29W3	4.0-26.0	11.5	0.1-90.0	9.05	48-100	88.00

TABLE 4. Summary of the porosity obtained from geophysical well logs for the Martin Sandy Zone.

Well Location	POROSITY % Range	Average
11-11-2-24W3	10.0-17.0	12.5
7-35-1-26W3	11.0-18.5	12.7
6-21-9-26-W3	18.0-27.0	23.4
7-6-10-26W3	16.0-28.0	22.9
7-10-2-27W3	11.0-28.5	19.5
11-12-2-28W3	11.0-19.0	14.5
10-6-4-28W3	15.0-21.0	17.4
7-15-4-28W3	16.0-27.0	20.0
10-3-3-29W3	15.0-20.5	17.5
7-25-6-29W3	16.0-28.0	21.5
9-21-6-30W3	15.0-30.0	26.0

an average of 80 percent.

Bowdoin Sandstone

The Bowdoin Sandstone occurs within the Carlile Formation of the Bowdoin dome in north-central Montana, and it is correlated with the Bowdoin Sandstone in southwestern Saskatchewan (Figs. 6, 11, 12, 13 and 14). In southeastern Alberta, the Bowdoin Sandstone unit is not recognized, and a largely argillaceous sequence intervenes between the main sandy units, the Second White Specks Sandstone and the Martin Sandy Zone (Figs. 7, 8 and 9).

The isopach map of the Bowdoin Sandstone in the study area (Fig. 17), shows a maximum thickness of 120 m in the southwest corner, with a decrease toward the northeast. The northeasterly thinning can be seen in Figures 12 and 14, and it is combined with increase of intercalated mudstone. In north-central Montana, the Bowdoin Sandstone reaches more than 80 m thick (Nydegger et al., 1979).

One core was obtained from the Bowdoin Sandstone at Tide Water Braddock Crown No. 1 well (Lsd 5-7-14-10W3). The unit consists of fine- and very fine-grained sandstones occurring in type-II and type-III elements, alternating with non-calcareous mudstone and shales (Henry, 1979, Fig. 3, p. 3), especially in the Bowdoin dome region of Phillips and Valley Counties, Montana (Rice and Shurr, 1978, 1980). In southwestern Saskatchewan the proportion of the intercalated shale is increasing (Figs. 6 and 14). Muddy siltstones also occur with the sandstones, they occur in clay-rich lenses and laminae usually less than 3 cm thick and interbedded with shales. Siltstones and sandstones consist dominantly of quartz with minor amounts of feldspar and pyrite (Nydegger et al., 1979). Pelecypod and fish-skeletal debris are abundant in the unit. The amount of clays and bentonites is important because they reduce the porosity and the permeability values of the unit. The Bowdoin Sandstone has porosities ranging from 8 to 14 percent and permeabilities ranging from less than 0.1 to 0.7 md (Nydegger et al., 1979), while Campen (1975) estimated porosity from density logs with values running from lows of 13 to 14 percent up to 24 to 25 percent with an average of 15 to 18 percent, and this can be seen in Campen (1975 Table VIII, p.24). In the study area, the porosity is obtained from SARABAND and well logs (Appendices III, IV). The SARABAND values have a range from 1 to 24 percent with an average of 12 percent. The porosities calculated from the geophysical well logs have a range from 10 to 30 percent with an average of 18.5 percent (Table 5). Permeability is obtained from the SARABAND logs and has a range from 0.1 to 50 md with an average of 2.1 md. Porosity and permeability values show upward increasing, probably related to the increasing and coarsening of the sandstones. The maximum values of the porosity and permeability occur at the top intervals of the unit (Fig. 19). Also, there is a decrease in porosity toward the eastern ranges of the study area (Range 24W3), and the highest average values occur in the western ranges (Ranges 29 and 30). This can be seen in Table 5.

Greenhorn Lime

The Greenhorn Lime unit is immediately above the Phillips Sandstone in the Upper Colorado sequence. The Greenhorn Lime is up to 6.5 m in thickness in northern Montana and southwestern Saskatchewan.

Greenhorn Lime cores are taken from seven locations within the study area and the descriptions of these cores are presented in Appendix I. The Greenhorn Lime is composed of fine-grained bioclastic chalky limestone, interbedded with silty, calcareous, speckled and bituminous mudstone. Mudstone occurs in layers, usually a few mm thick. Limestone and chalk occur as layers ranging from less than 1 mm to about 2 cm thick, with thin layers most abundant, and they occur in lenticular and continuous, with horizontal and cross-lamination layers frequently graded. Pyrite concretions are localized in the plane of bedding in some limestone layers. *Inoceramus* shells and

Table 5. Summary of the porosities obtained from geophysical well logs for the Bowdoin Sandstone.

	POROSITY %	
Well Location	Range	Average
11-11-2-24W3	10.0-16.5	13.2
7-35-1-26W3	8.5-18.0	14.1
6-21-9-26W3	13.0-27.0	21.0
7-6-10-26W3	15.5-23.5	20.0
7-10-2-27W3	11.0-26.0	14.6
11-12-2-28W3	13.5-23.0	14.5
10-6-4-28W3	14.0-23.0	17.8
7-15-4-28W3	13.5-20.0	19.0
10-3-3-29W3	14.0-26.0	17.7
7-25-6-29W3	14.0-26.0	21.0
9-21-6-30W3	17.0-30.0	25.0

debris, and pelecypod and fish-skeletal debris are incorporated with the chalky limestone. The base of the unit is marked by interbedded bentonitic layers which range in thickness from 0.5 cm up to 25 cm thick at about 815.75 m depth as in the UBR Amoco Senate 10-9-3-28 well (Lsd 10-9-3-28W3). The bentonite layers are mostly horizontally laminated, but cross-laminated at the top and make a sharp contact with the top of the Phillips Sandstone. Since the bentonite layers are impermeable, they affect the response of the resistivity logs by giving a relatively high peak which can be seen in all the cross sections (Fig. 6 through 15), immediately above the Phillips Sandstone. It also provides a seal for gas entrapment in the Phillips Sandstone of north-central Montana (Nydegger et al., 1979, p. 317).

The porosity, permeability and water saturation of the unit in the study area were obtained from one core analysis (UBR Noel Senate 11-28-2-28-W3) taken at depth between 2627 and 2648 feet (800.7-807.1 m), and can be seen in Appendix II. The porosity values range from 6.8 to 16.7 percent with an average of 14 percent, which is a relatively low value because of the calcareous lithology of the unit. The permeability values are ranging from 0.1 to 1.6 md with a 0.5 md average and with the highest values occuring at the bottom while the lowest values occur at the top of the unit. The water saturation ranges from 50 to 80 percent with an average of 65 percent.

Phillips Sandstone

In southwestern Saskatchewan, the Phillips Sandstone occurs within the Second White-Speckled Shale, while in southeastern Alberta, the sandy unit within the Second White-Speckled Shale have been designated the Second White-Specks Sandstone (Figs. 7, 8 and 9). In the Bowdoin dome region, the basal sandstones of the Phillips Sandstone occupy the upper part of the Belle Fourche Formation (Nydegger et al., 1979). The Phillips Sandstone appears to be largely restricted to the Second White-Speckled Shale in southwestern Saskatchewan with the exception of the area around Monchy (Fig. 14). In the East Keith gas field of northern Montana, the Phillips Sandstone occurs immediately above the Lower Colorado Fish-Scale Marker (Fig. 15).

The isopach map of the Phillips Sandstone shows a maximum thickness more than 70 m (Fig. 18). In the Bowdoin dome area, the Phillips Sandstone reaches up to 50 m in thickness (Nydegger et al., 1979). The isopach map shows a decrease in thickness toward the northeast within the study area. The passage from a relatively thick Phillips sequence to a thinner unit with reduced sand content is observed across a northwesterly belt, shown in Figure 20 and can be seen also in Simpson (1975, Fig. 6, p. 570). Figures 12, 13 and 14 are characterized by a progressive northeasterly increase of intercalated mudstone combined with northeasterly thinning and attenuation of the lowermost sandy strata of the Phillips Sandstone.

The lithological descriptions for the Phillips Sandstone are based on nine cores taken from the study area. It consists of fine- and very fine-grained, quartzose, coccolithic sandstones and siltstone, alternating with layers of calcareous shale and mudstone. Sandstones and siltstones are frequently graded lenses and continuous layers up to 5 cm thick, mostly in the order of few mm, with low-angle cross-lamination and horizontal lamination. *Inoceramus* fragments and fine debris, fish-skeletal debris, and phosphorite pebbles are also common. Burrows are present in the form of sand-filled tubes, mostly horizontal and less frequently inclined at low angles to the bedding. The proportion of mudstone and siltstone increases downwards. The top of the unit is marked by strongly indurated, calcite-cemented sandstones and siltstones which occur immediately below several bentonite layers, and act as a cap rock the unit, in southwestern Saskatchewan.

The porosities and permeabilities are strongly affected by the vertical variation in the lithology. The maximum values always occur at the top of the unit (Fig. 19), which is related to the upward coarsening. Also, there is northeasterly decrease in the values of the porosity and permeability which is also related to the increase in the amount of intercalated mudstone in that direction.

The porosity obtained from the geophysical well logs ranges from 9 to 29 percent with an average of 19.5 percent (Table 6). The maximum values occur at the top of the unit and the minimum values toward the base (Fig. 19). The porosity obtained from the SARABAND log has a range between 1 and 20 percent and a 3.2 percent average. The core analysis porosity values range from 9.9 to 29.7 percent with an average of 19.8 percent (Table 7), and the maximum values are at the top of the unit.

The permeability was obtained from the SARABAND logs and core analyses. The values calculated from SARABAND logs range from 0.1 to 50 md with 1.9 md average. The permeability values obtained from core analyses (Table 7), range from as low as 0.1 md to as high as more than 100 md, with some values reaching up to 235 md as in UBR Noel Senate 11-28-2-29 well (Lsd 11-28-2-28W3) at a depth of 2656.0 feet (809.54 m) to 2656.9 feet (809.82 m), and with 195 md in the UBR Amoco Battle Creek 6-17-6-28 well (Lsd 6-17-6-28W3) at 3224.2 feet (982.73 m) to 3224.9 feet (983.0 m). The maximum values are found toward the

TABLE 6. Summary of the porosities obtained from geophysical well logs for the Phillips Sandstone

Well Location	POROSITY %	
	Range	Average
11-11-2-24W3	9.0-14.0	12.3
7-35-1-26W3	9.5-15.5	12.4
6-21-9-26-W3	11.0-25.0	20.5
7-6-10-26W3	12.0-24.5	20.5
7-10-2-27W3	8.5-18.5	12.2
11-12-2-28W3	12.5-18.5	13.8
10-6-4-28W3	12.5-18.0	16.0
7-15-4-28W3	15.0-20.5	17.5
10-3-3-29W3	23.0-28.5	26.5
7-25-6-29W3	14.0-28.0	22.5
9-21-6-30W3	15.6-29.0	26.7

top of the unit. The water saturation obtained from core analyses range between 31 and 87 percent with an average of 70 percent (Table 7). The values calculated from SARABAND log range from 70 to 100 percent with 98 percent average, while the values from well logs range from 50 to 100 percent with an average of 90 percent.

The average porosity and water saturation values obtained from core analyses are consistent with the values obtained from well log analyses which are more reliable. The values obtained from SARABAND analyses are remarkably different from core and well log analyses values, so they are not reliable.

Sandstones of Montana Group

The Montana Group (Santonian to Maestrichtian) is made up of marine shale, interdigitating with sandstones and siltstones tongues of continental and fluvio-marine origin (Nichols and Wyman, 1969; McLean 1971). In western Saskatchewan, the Belly River Formation contains three sandstone tongues. They are listed in order of increasing age: Oldman, Ribstone Creek and Victoria Tongues. The dominantly argillaceous Lea Park Formation contains three tongues also, listed in order of increasing age: Grizzly Bear, Vanesti and Shandro Tongues.

The Ribstone Creek Tongue of the Belly River Formation

TABLE 7. Summary of the porosity, permeability, and water saturation obtained from core analysis for the Phillips Sandstone.

Well Location	POROSITY %		PERM. (md)		WATER SAT. %	
	Range	Average	Range	Average	Range	Average
11-8-2-28W3	16.4-26.5	22.33	0.1-117.0	14.00	57.0-82.0	71.20
11-28-2-28W3	14.7-27.9	21.50	0.1-235.0	20.40	31.0-86.0	61.50
10-9-3-28W3	9.9-25.9	20.61	0.2-31.0	3.71	37.5-82.6	62.26
6-17-6-28W3	19.9-29.7	23.90	0.59-195.0	25.00	53.6-84.6	68.0
10-19-3-29W3	13.4-29.0	20.61	0.1-7.4	0.78	56.6-87.4	76.0

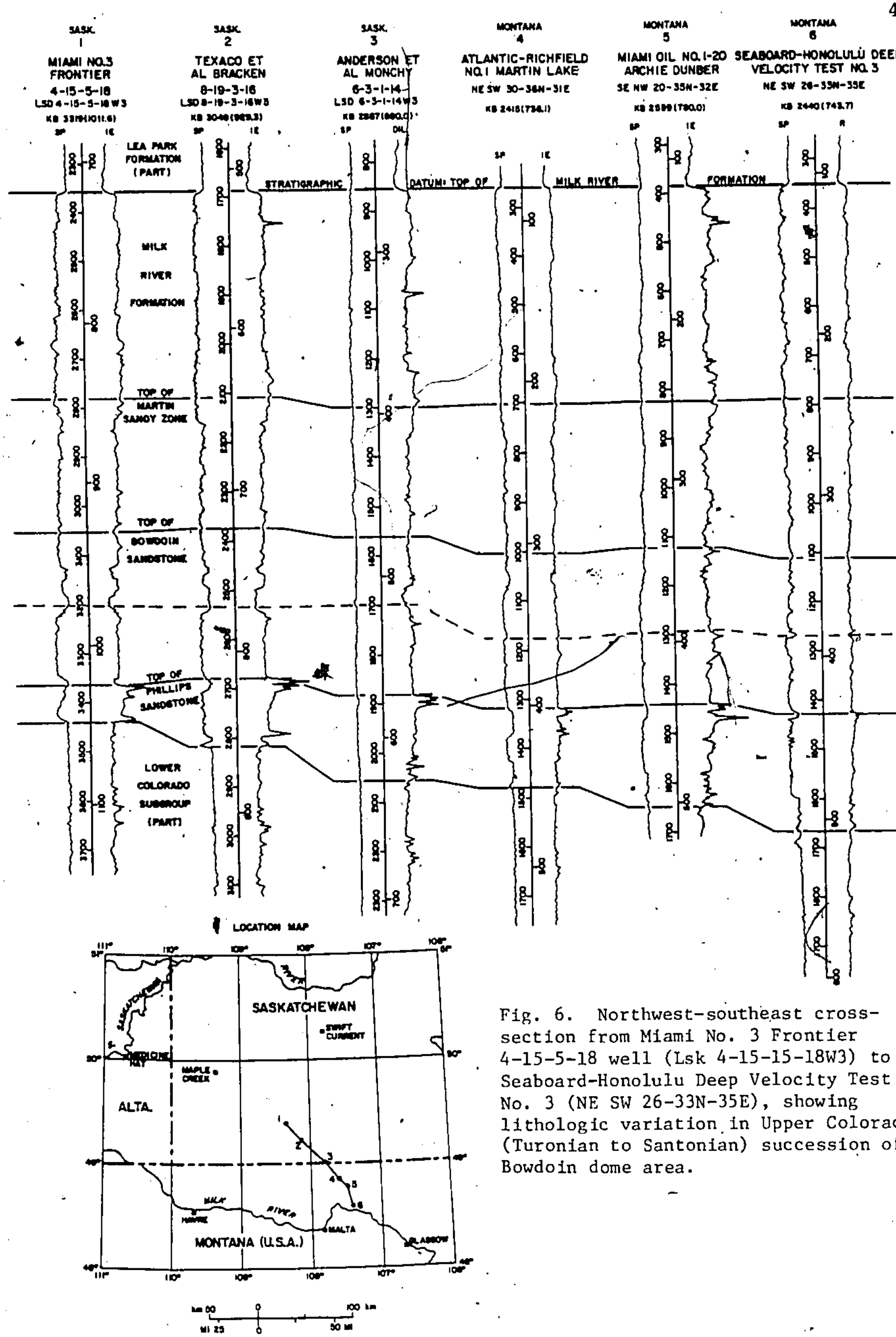


Fig. 6. Northwest-southeast cross-section from Miami No. 3 Frontier 4-15-5-18 well (Lsk 4-15-15-18W3) to Seaboard-Honolulu Deep Velocity Test No. 3 (NE SW 26-33N-35E), showing lithologic variation in Upper Colorado (Turonian to Santonian) succession of Bowdoin dome area.

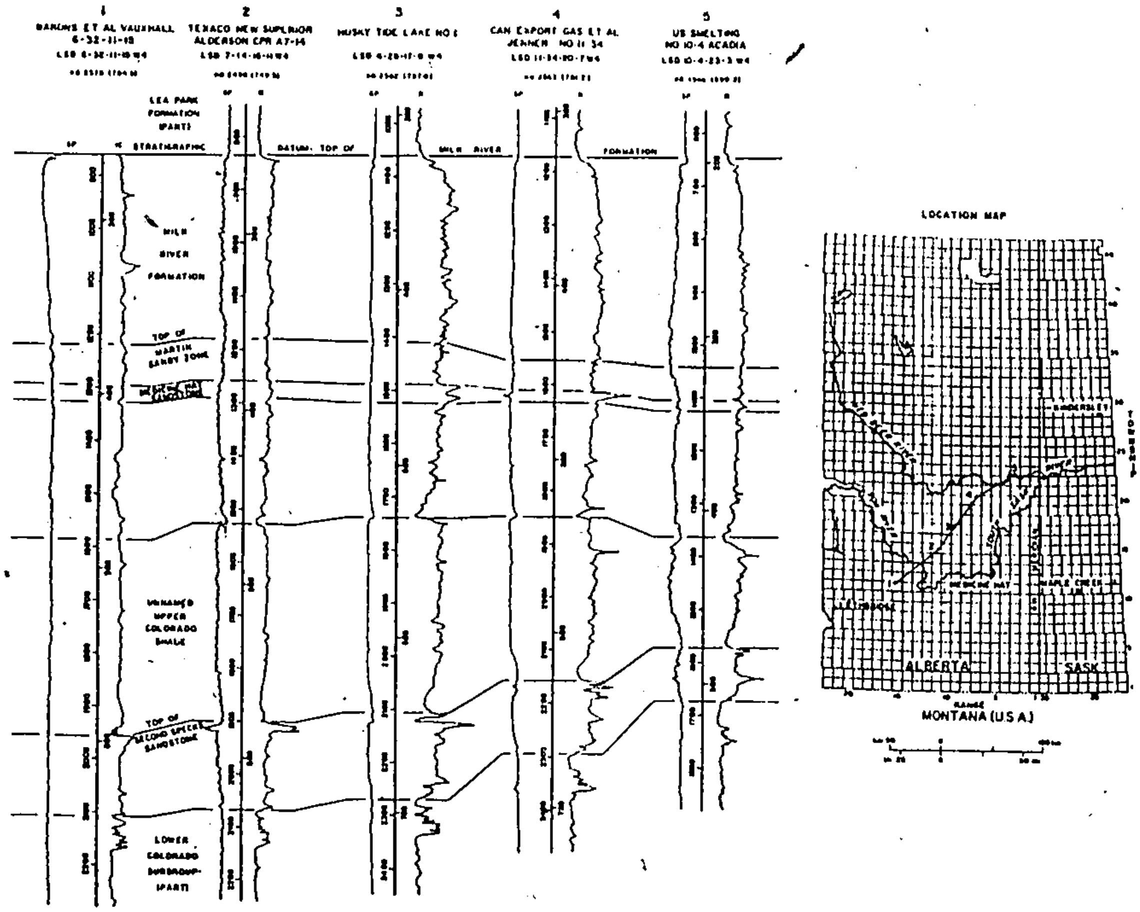


Fig. 7. Southwest-northeast cross-section from Barans *et al* Vauxhall 6-32-11-15 well (Lsd 6-32-11-15W4) to U.S. Smelting No. 1-4 Acadia well (Lsd 10-4-23-3W4), showing lithologic variation in Upper Colorado (Turonian to Santonian) succession of southeastern Alberta.

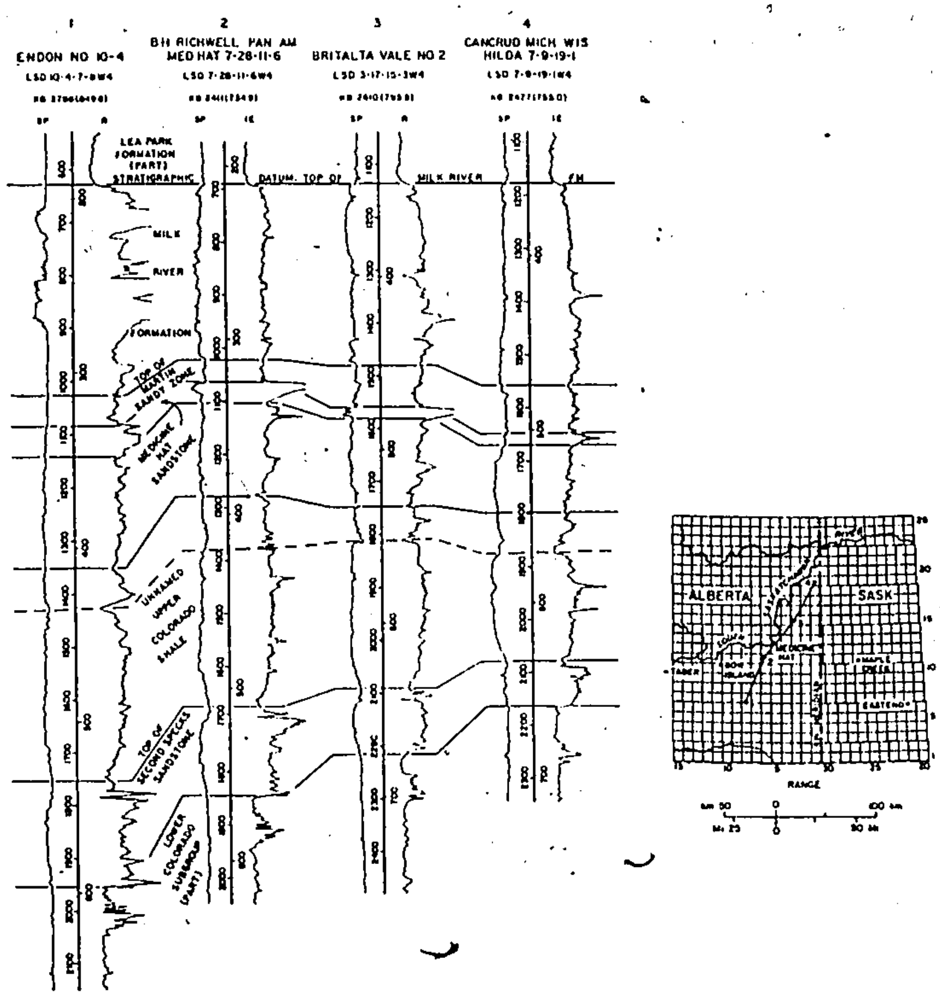
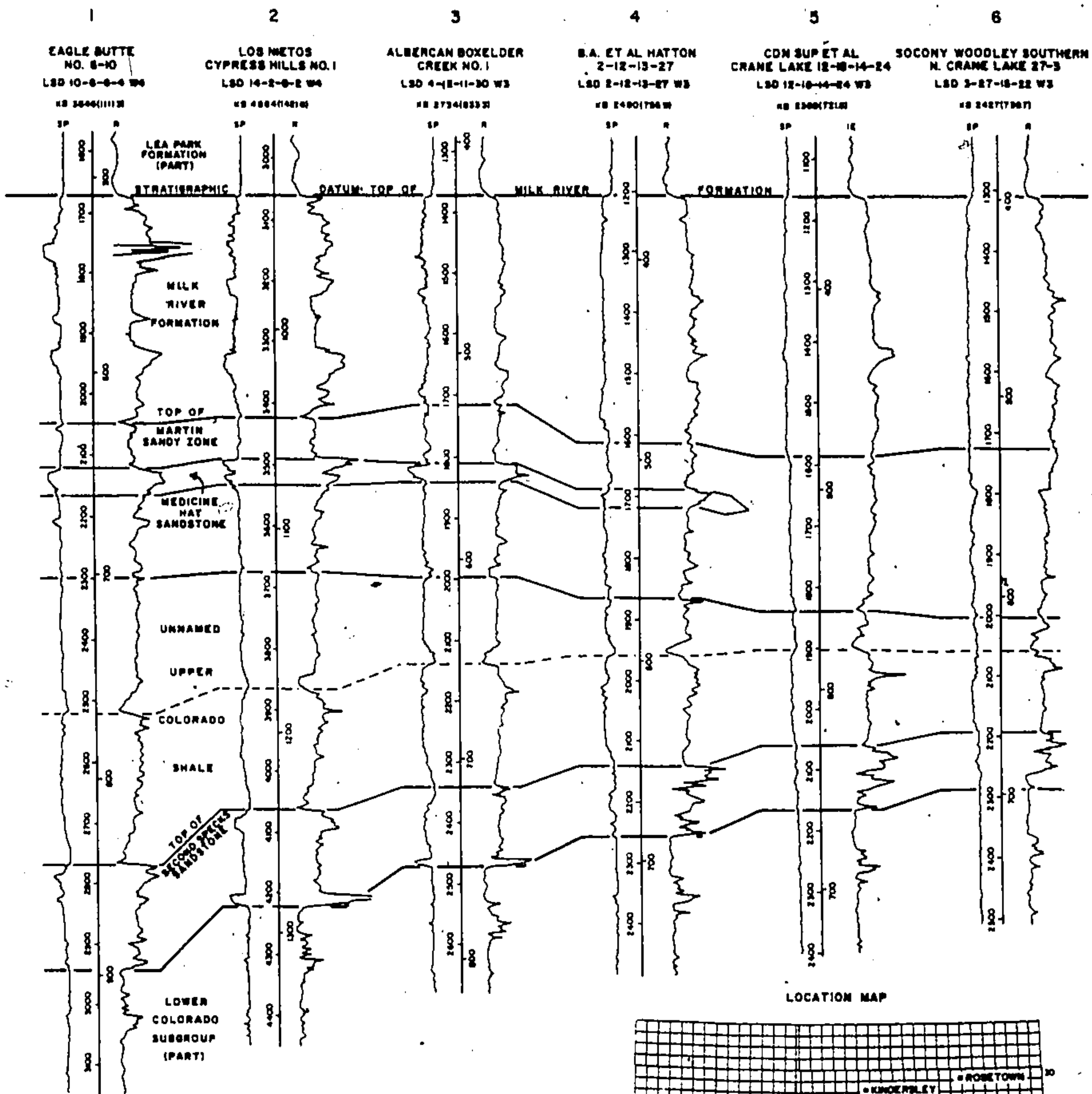


Fig. 8. Southwest-northeast cross-section from Endon No. 10-4 well (Lsd 10-4-7-8W4) to Cancrud Mich Wis Hilda 7-9-19-1 well (Lsd 7-9-19-1W4), showing lithologic variation in Upper Colorado (Turonian to Santonian) succession of southeastern Alberta.



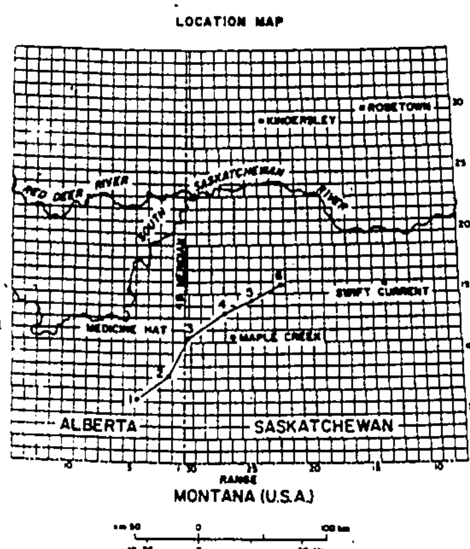


Fig. 9. Southwest-northeast cross-section from Eagle Butte No. 6-10 well (Lsd 10-6-6-4W4) to Sacony Woodley N. Crane Lake 27-3 well (Lsd 3-27-15-22W3), showing lithologic variation in Upper Colorado (Turonian to Santonian) succession of southeastern Alberta and southwestern Saskatchewan.

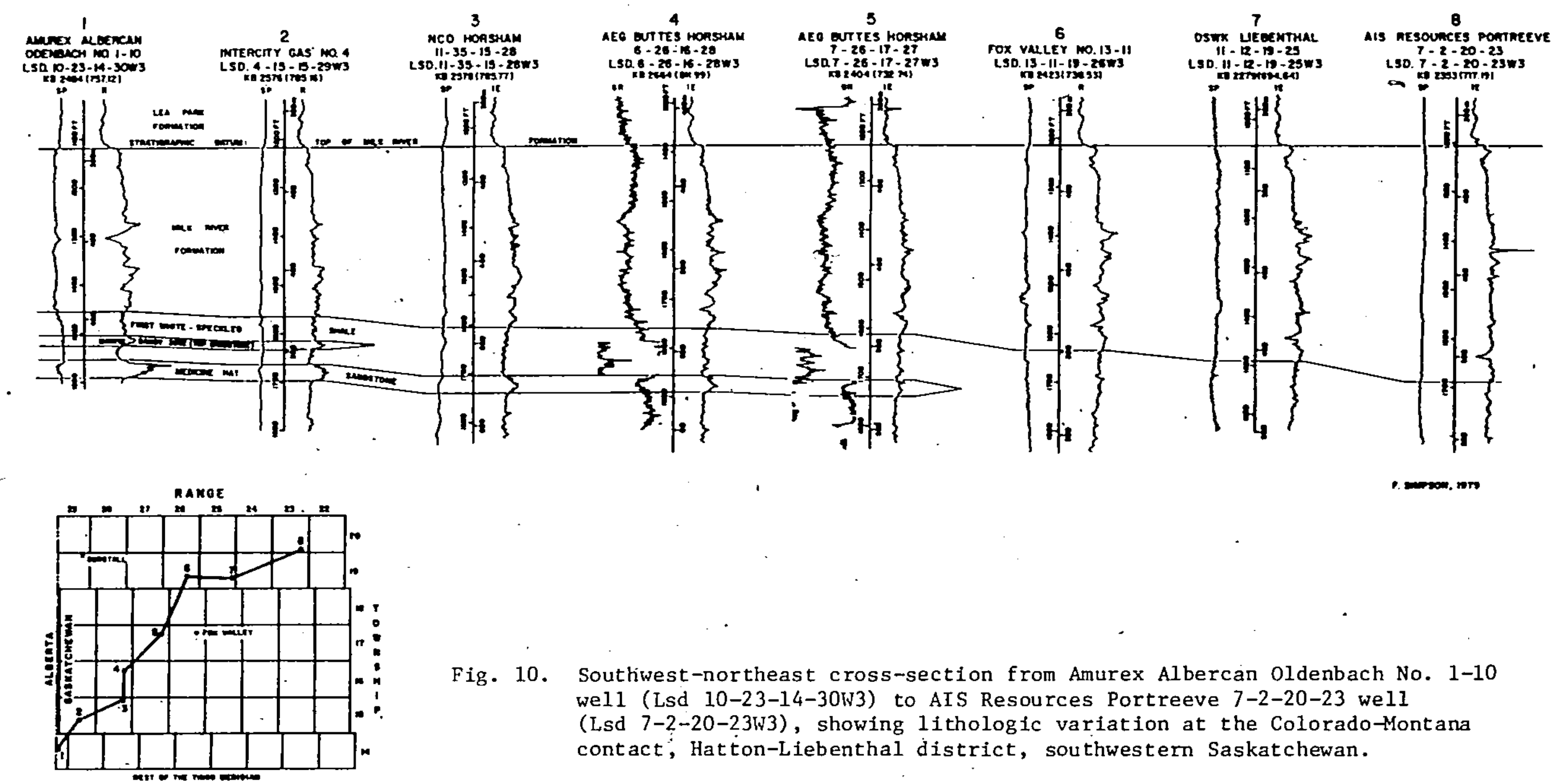


Fig. 10. Southwest-northeast cross-section from Amurex Albercan Oldenbach No. 1-10 well (Lsd 10-23-14-30W3) to AIS Resources Portreeve 7-2-20-23 well (Lsd 7-2-20-23W3), showing lithologic variation at the Colorado-Montana contact, Hatton-Liebenthal district, southwestern Saskatchewan.

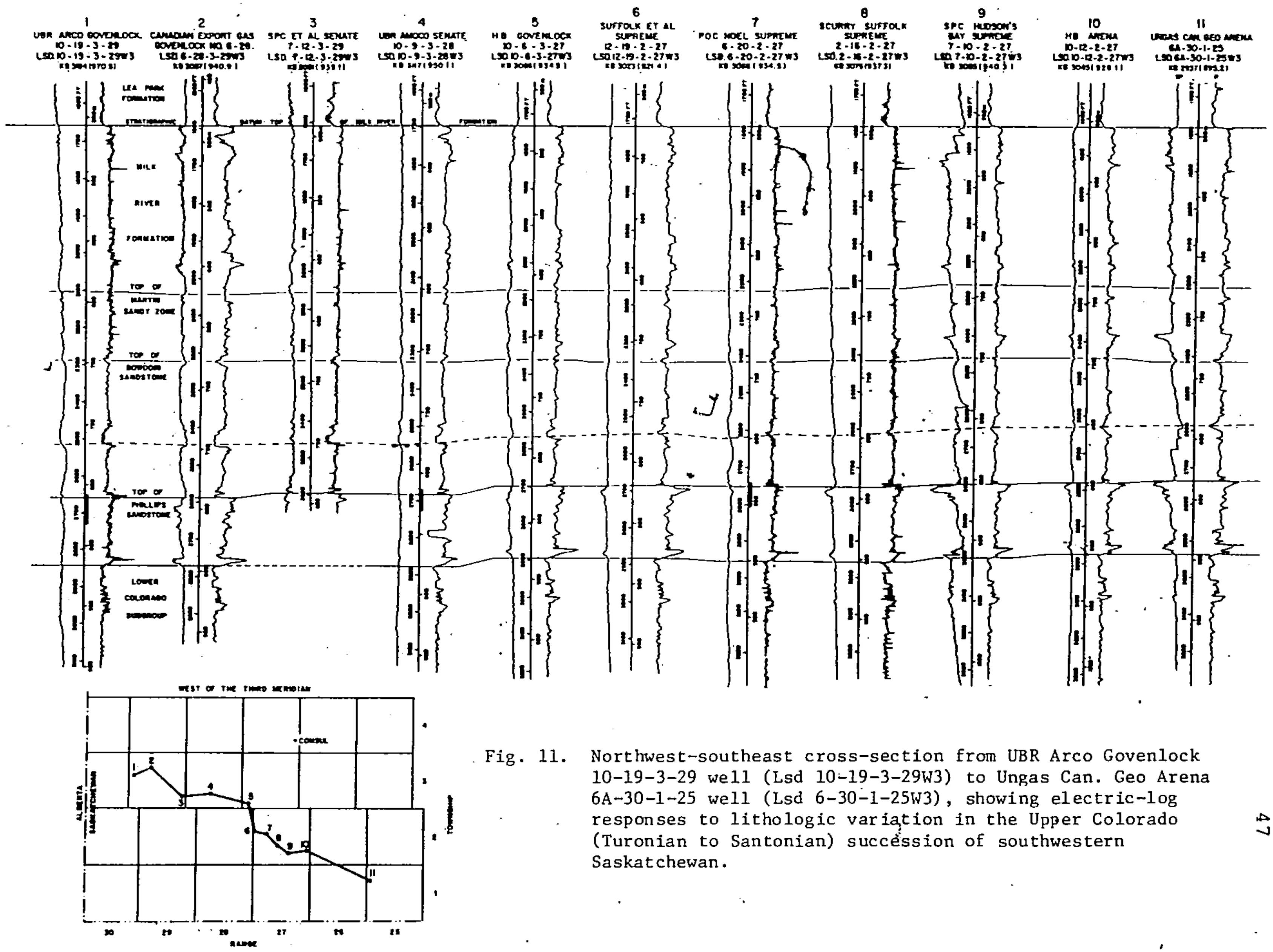


Fig. 11. Northwest-southeast cross-section from UBR Arco Govenlock 10-19-3-29 well (Lsd 10-19-3-29W3) to Ungas Can. Geo Arena 6A-30-1-25 well (Lsd 6-30-1-25W3), showing electric-log responses to lithologic variation in the Upper Colorado (Turonian to Santonian) succession of southwestern Saskatchewan.

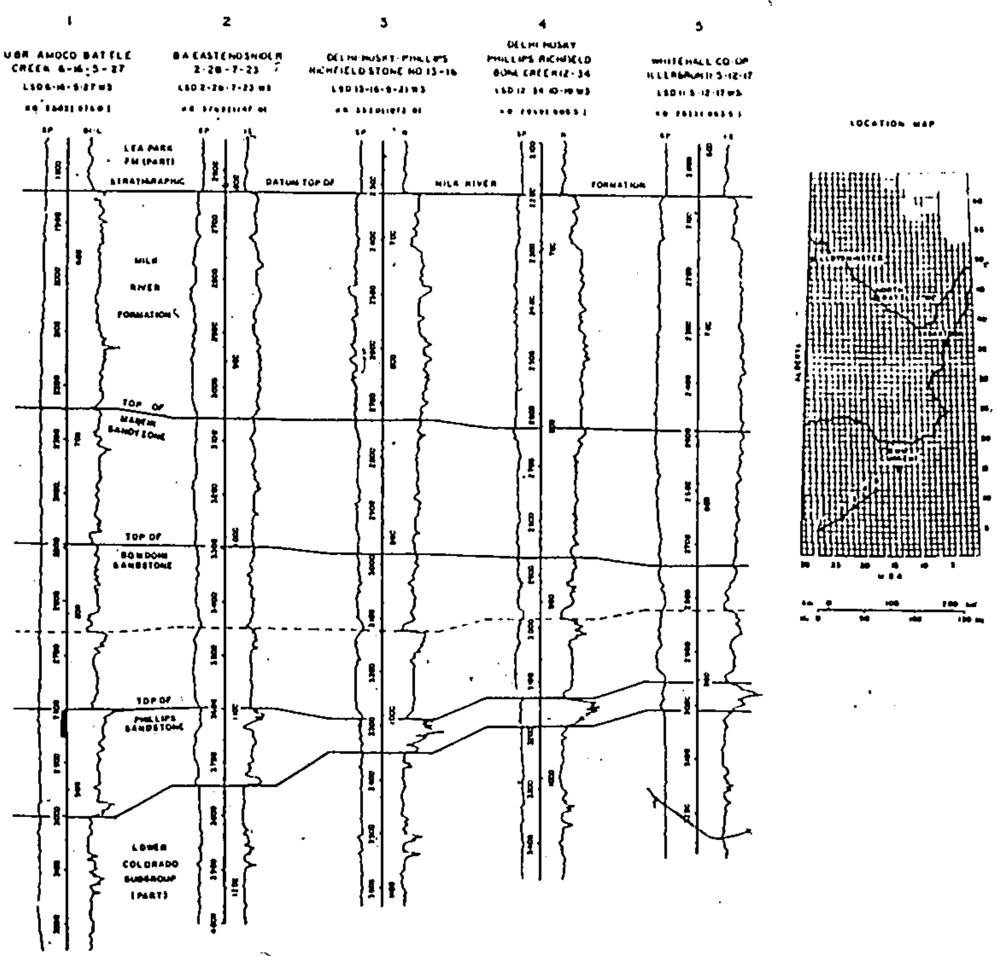


Fig. 12. Southwest-northeast cross-section from UBR Amoco Battle Creek 6-16-5-27 well (Lsd 6-16-5-27W3) to Whitehall Coop 11-5-12-17 well (Lsd 11-5-12-17W3), showing lithologic variation in Upper Colorado (Turonian to Santonian) succession of southwestern Saskatchewan.

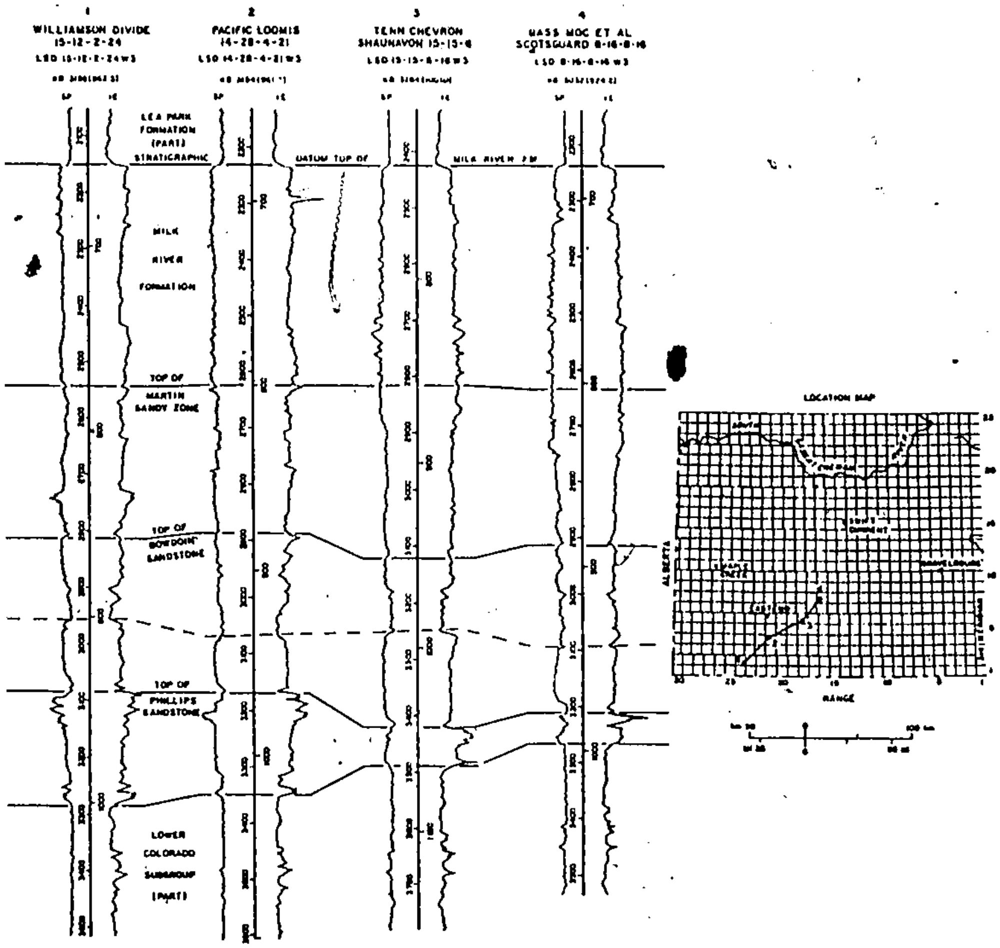


Fig. 13. Southwest-northeast cross-section from Williamson Divide 15-12-2-24 well (Lsd 15-12-2-24W3) to Bass Moc et al Scotsguard 8-16-8-16 well (Lsd 8-16-8-16W3), showing lithologic variation in Upper Colorado (Turonian to Santonian) succession, of southwestern Saskatchewan.

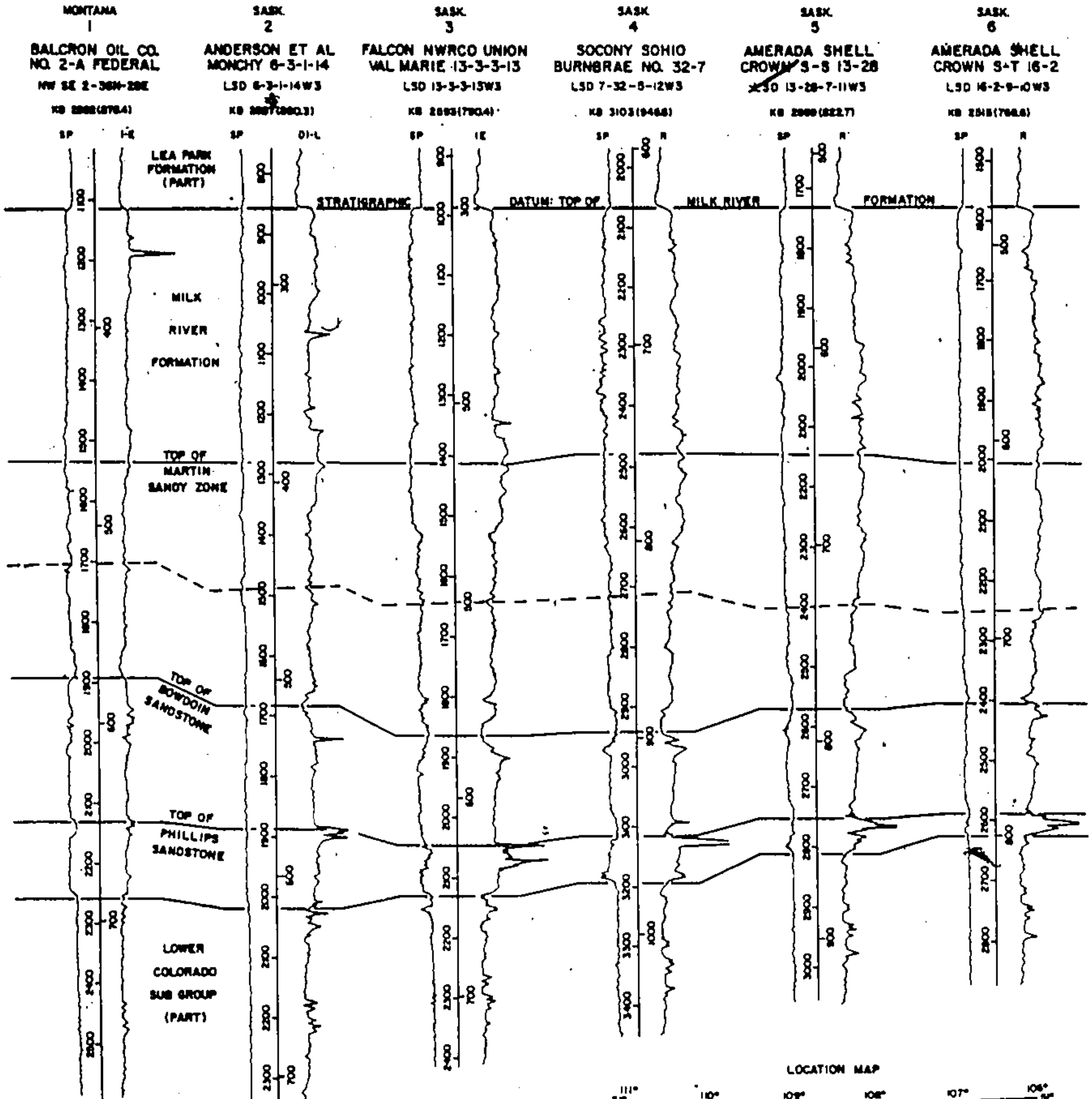
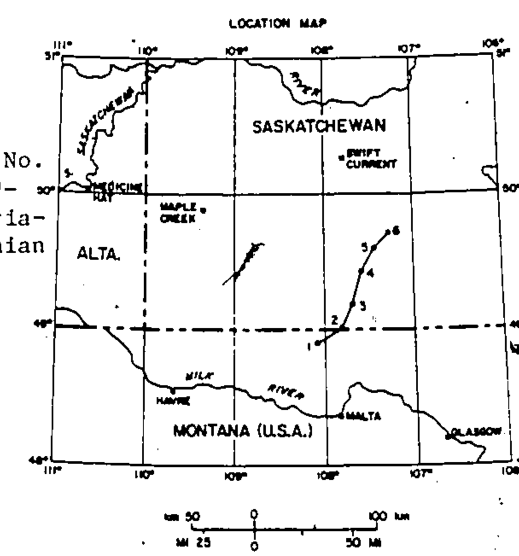


Fig. 14. Southwest-northeast cross-section from Balcron Oil Co. No. 2-A Federal well (Lsd 16-20-9-10W3), showing lithologic variation in Upper Colorado (Turonian to Santonian) succession of north- central Montana and southwestern Saskatchewan.



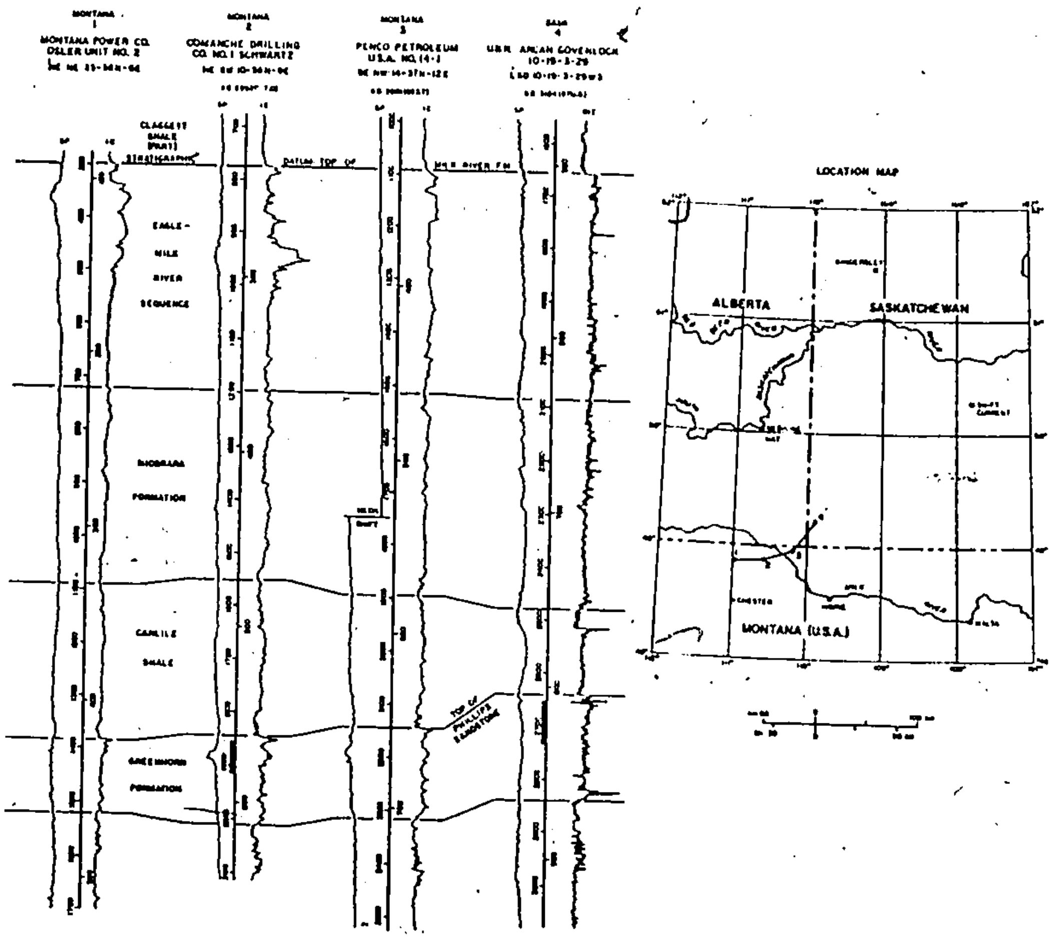
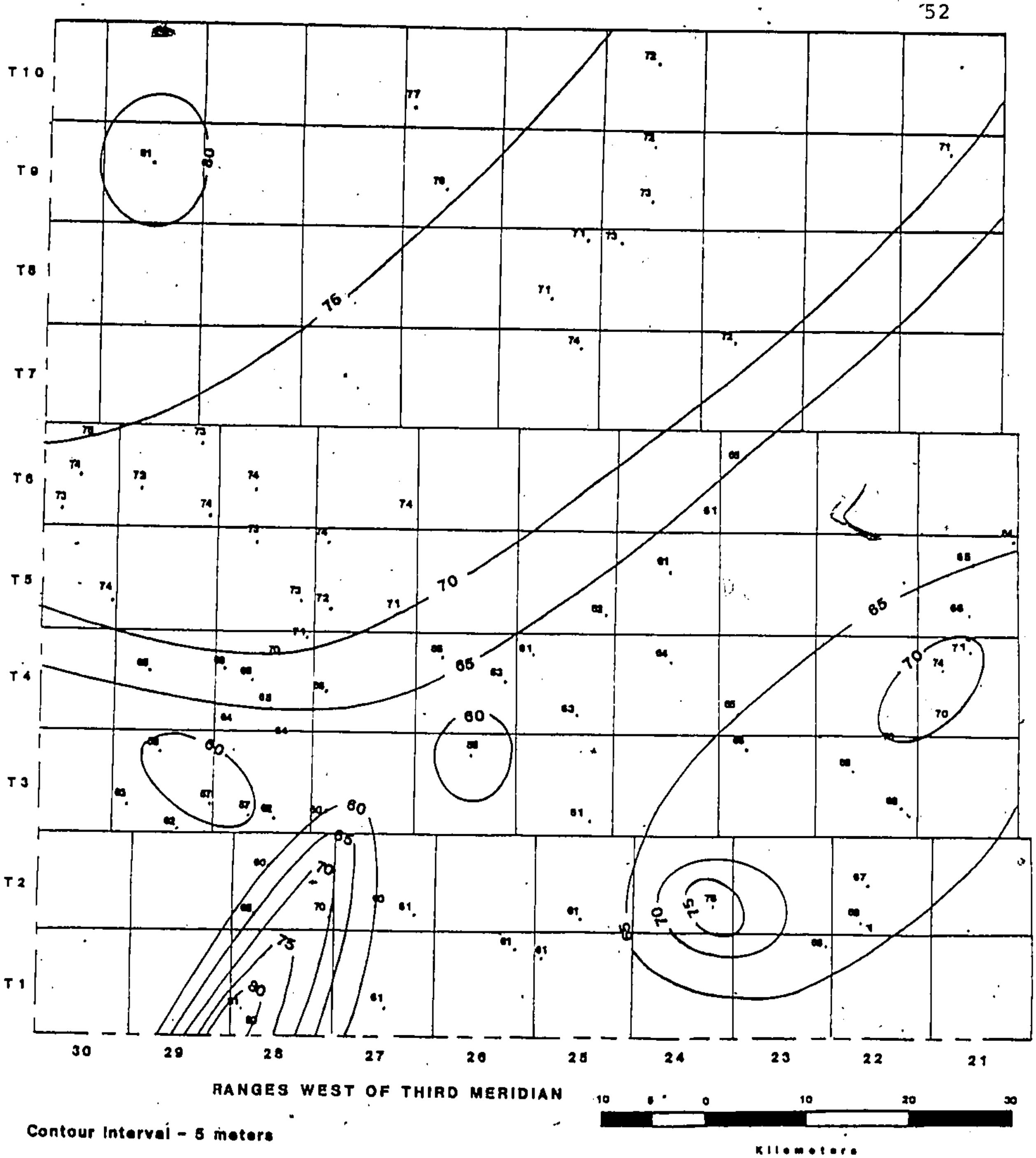
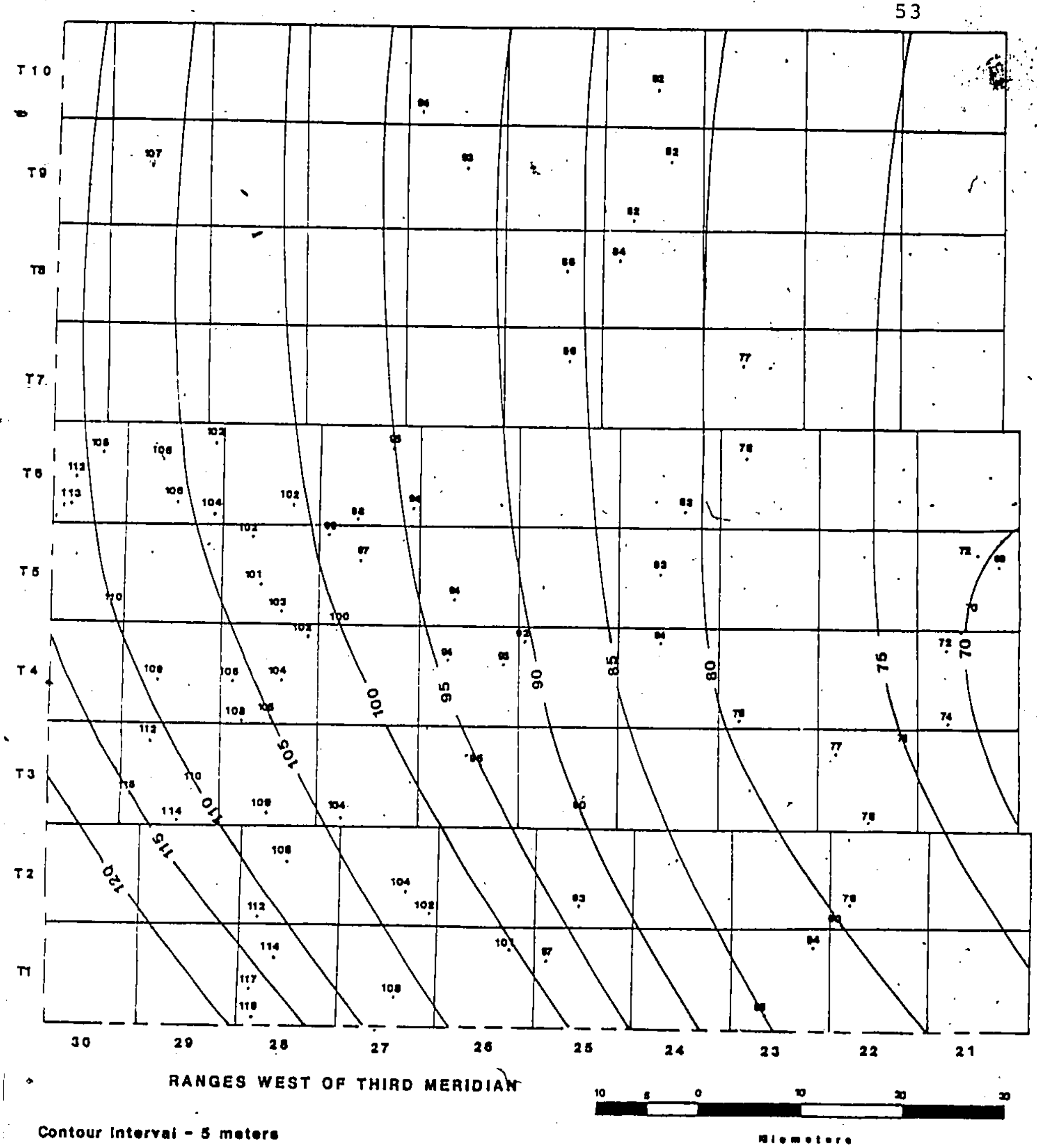


Fig. 15. West-southwest-east-northeast cross-section from Montana Power Co. Osler Unit No. 2 well (NE NE 23-36N-6E) to UBR Arco Govenlock 10-19-3-29 well (Lsd 10-19-3-29W3) showing lithologic variation in Upper Colorado (Turonian to Santonian) succession of north-central Montana, southeastern Alberta and southwestern Saskatchewan.



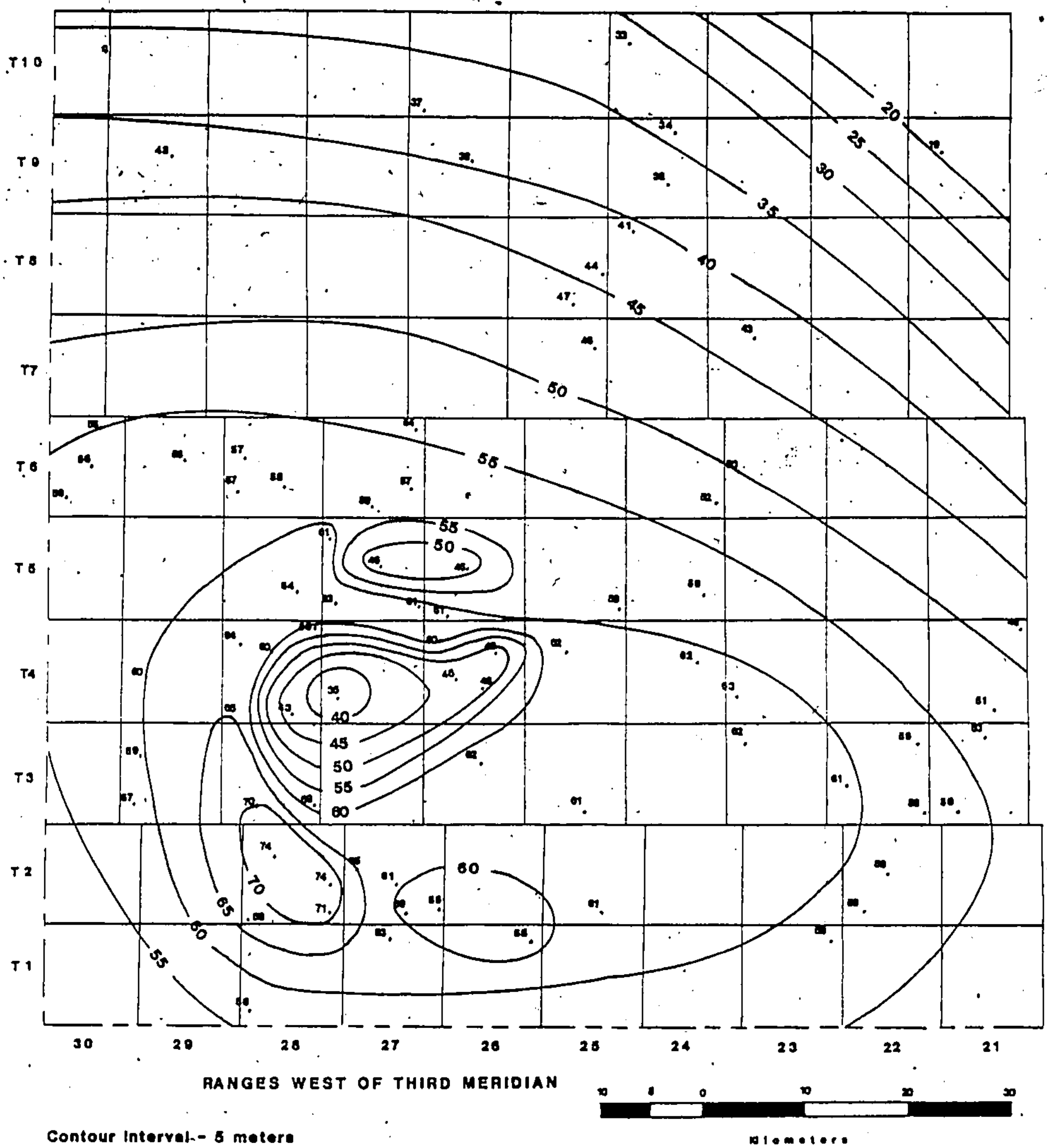
ISOPACH MAP FOR
THE MARTIN SANDY ZONE
IN SOUTHWESTERN SASKATCHEWAN

Figure -16



ISOPACH MAP FOR THE BOWDOIN SANDSTONE IN SOUTHWESTERN SASKATCHEWAN

Figure — 17



ISOPACH MAP FOR THE PHILLIPS SANDSTONE IN SOUTHWESTERN SASKATCHEWAN

Figure -18

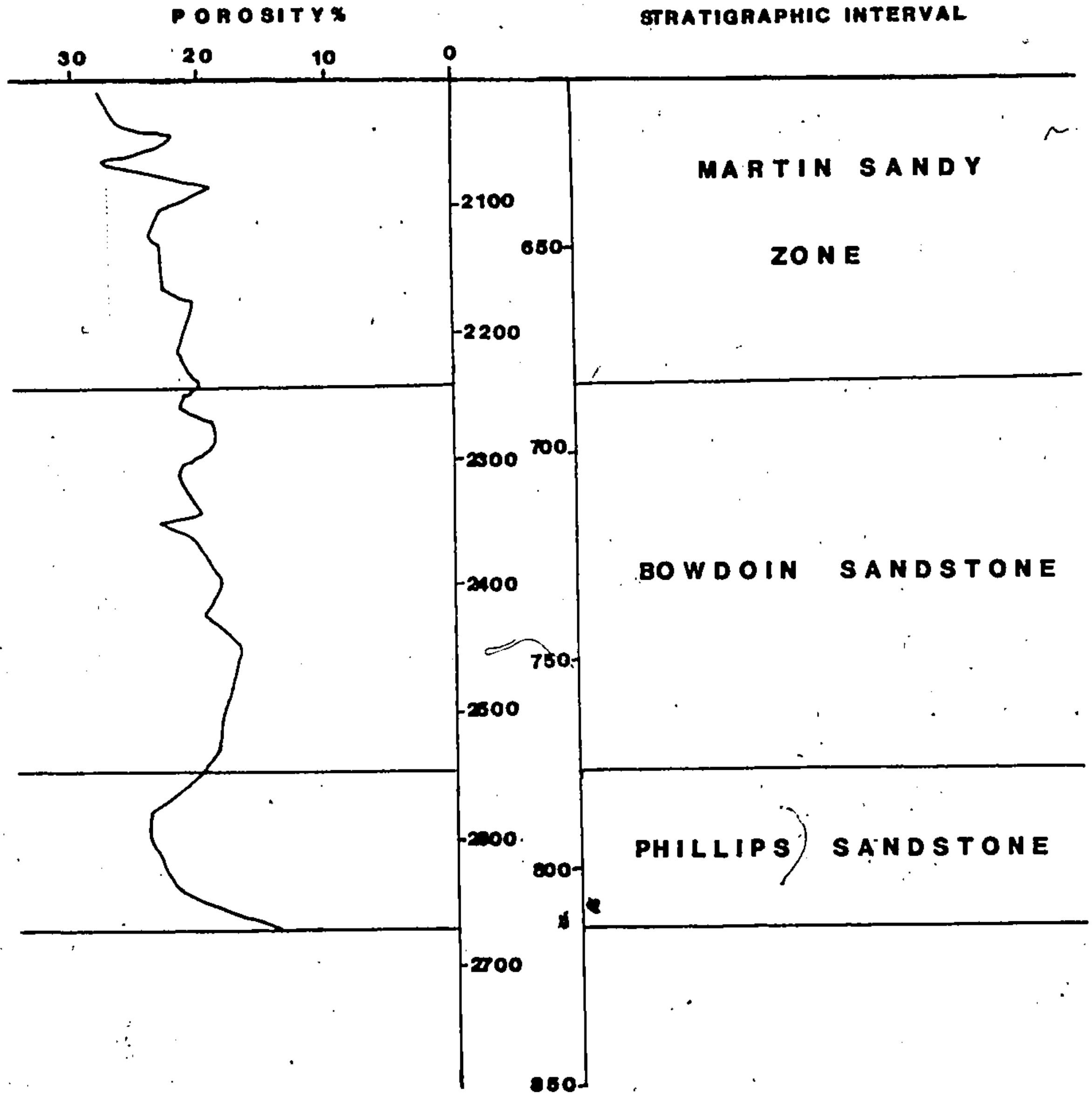


Fig. 19. Porosity variation with depth in the Upper Colorado succession of the SPC Shell Maple Creek 7-6-10-26 well (Lsd 7-6-10-26W3) of southwestern Saskatchewan.

consists of fine-grained, quartzose, micaceous, glauconitic sandstones. They occur in type-III, and -IV elements which are arranged in coarsening-upward sequences. They are capped by a strongly indurated layer with calcite and siderite-ankerite cemented sandstone. Feldspathic arenites and feldspathic graywackes are also common (Simpson, 1979d, 1980).

The Milk River Formation (Campanian) consists of bioturbated, muddy siltstones and fine-grained sandstones occur in type-III elements, which incorporate scarces, flattened lenses of fine- and very fine-grained sandstones. The formation includes pods of lithic graywacke with a matrix of siderite, and clay separated by mudstone stringers. Nodular siderite and phosphorite are present with pyrite segregations, and scattered mollusca and fragments of fish-skeletal debris. The unit is characterized by only slight vertical variation in lithology with minor differences in mud content (Simpson, 1979d).

One geophysical density log was analyzed to obtain the porosity of the Milk River Formation. The well is SPC Merryflat 7-19-6-28 (Lsd 7-19-6-28W3) at depth between 2224 feet (677.9 m) and 2632 feet (802.2 m). The porosity ranges between 13 and 19.5 percent with a 16 percent average (Appendix IV).

The SARABAND porosity values of the Milk River

Formation were obtained from the SPC Vidora 10-21-4-26 well (Lsd 10-21-4-26W3) at depth between 1869 and 2187 feet (569.7 to 666.6 m) and can be seen in Appendix III. They range from 10.7 to 20.2 percent with a 15 percent average. The core analysis porosity values were obtained from the AEG Horsham 11-8T-18-29 well (Lsd 11-8T-18-29W3) and have a range from 10.2 to 26.2 percent. The permeability was obtained from SARABAND log and core analyses, and can be seen in Appendix II. The SARABAND values range from 0.2 to 20 md with a 3.8 md average while the core analysis values range from 0.1 to 5.26 (with one of 58) md from a depth of between 1496.3 (456.07 m) and 1496.4 (456.10 m). The water saturation estimated from the SARABAND log ranges from 61 to 100 percent with an 80 percent average while the core analysis values range from 48.7 to 89 percent with an 80 percent average also.

Lower Colorado Sandstone Bodies

The Lower Colorado Subgroup (Middle Albian to Cenomanian) is divided into three main units listed in order of decreasing age: The Joli Fou, Viking and Big River Formations.

The Joli Fou and Big River Formations are made up of dark-grey, non-calcareous mudstones and shales. Some irregular lenses of very fine-grained, quartzose sandstone, silty mudstone, bentonite and siderite occur. In west-central Saskatchewan a strongly glauconitic sandstone is present which appears to be genetically related to the Spinney Hill Sandstone of central Saskatchewan. Fish-skeletal debris of graded sandstone alternating with mudstone is common in the upper part of the Big River Formation to form the Fish-Scale Marker unit.

The Bow Island-Viking clastic wedge consists of multistory arrangements of sandstone bodies in which coarsening-upward sequence occur. The sandstone bodies are made up of fine- and very fine-grained, quartzose, micaceous and kaolinitic sandstone of type-II and type-III elements, with upward coarsening accompanied by upward decrease in the proportion of mudstone. Type-IV and type-V elements are infrequently seen and occur at the tops of the coarsening-upward sequences. In eastern Saskatchewan, the sandstones of the Viking Formation show fining-upward arrangement (Simpson, 1979c). Sandstones and siltstones intercalcations in mudstones and shales from the base of the Fish-Scale Marker to the top of the First Bow Island Sand in the Lower Colorado sequence of northern Montana have been designated the Spikes Zone by Campen (1975). The lower limit of the Spikes Sandstone in Saskatchewan occurs at the top of the Viking Formation, which may be equivalent to the Second and Third Bow Island Sands.

The Spikes Zone has porosity ranges from as low as 9 to 10 percent to as high as 23 to 24 percent in the Liberty County of northern Montana (Campen, 1975). The Viking Formation has average porosity values ranging from 21 to 30 percent, and connate water saturation has an average range from 32 to 45 percent (Saskatchewan Reservoir Annual, 1979).

FORMATION FLUIDS

General Remarks

The water saturation in the petroleum reservoir is very important to determine the character of hydrocarbon field waters. The measuring of water saturation can be obtained by laboratory analysis of cores and by calculating the formation water resistivity from electrical logs.

The distribution of gas and water in the reservoir depends on many factors, such as: porosity, permeability, composition and hydrodynamic condition of the reservoir. It is also affected by the relative buyoancy, relative saturation, and the capillary and displacement pressure (Levorsen, 1954).

This account of the formation fluids is based on water and gas analyses, and on the drill stem tests for the Upper Colorado Subgroup.

Formation-Water Resistivity

Formation water resistivity (Rw) is an important factor in determination of the water saturation from electrical logs. The formation water resistivity can be obtained from the spontaneous potential (SP) curve, but in some cases it may be inadvisable to use this value as, for example, in situations involving very low permeability formations, depleted-pressure formations, and very heavy muds. This is because of the electrokinetic potential effects which result from the pressure difference across the formation. These potentials are large in cases noted above and they also depend on the resistivity of the electrolyte which is affected by the mud density.

The formation water resistivity can be derived from the resistivity-porosity plots (sonic and density porosities). It can also be obtained from the resistivity logs. An accurate estimate of the formation water resistivity can be obtained from chemical analyses of the formation waters.

The most common positive ions in petroleum reservoir waters are Mg^{++}, Ca^{++}, Na^{+}, K^{+}. Li^{+}, Fe (total) and Ba^{++} may also be present. The most common negative ions are Cl^{-}, $SO_4^{=}$ and HCO_3^{-} and less commonly $CO_3^{=}$, NO_3^{-}, Br^{-}, I^{-} and $S^{=}$. The concentration of dissolved solids is usually found to increase with depth. The amount of Ca^{++}, Cl^{-} and sometimes Mg^{++} are useful in detecting acid contamination of production samples (Noad, 1962). Water analysis is also useful for identification of the source of water produced along with oil or gas (Noad, 1962).

The formation water resistivity was obtained from the chemical analyses from nineteen wells from different locations within the study area. The values of the formation resistivity (Rw) in ohm-meters and the total solids concentration in milligrams per liter are listed in Appendix VI with the depth intervals and the equivalent stratigraphic intervals.

The formation water resistivity for the Phillips Sandstone obtained from the chemical analyses has a range from 0.208 to 1.66 ohm-meters, with one value of 2.50 ohm-meters at the SPC Notukeu 11-6-5-27 well (Lsd 11-6-5-27 W3). The formation water resistivity for the Medicine Hat Sandstone ranges from 0.374 to 0.876 ohm-meters with a range in total solids concentration from 5920 to 26050 mg/l.

The resistivity of the formation water which was obtained from the chemical analyses has an inverse relation with the total solids concentration at a constant temperature (Appendix VI). It appears that it decreases with increase in the total solids concentration.

Hitchon (1964), Hitchon et al. (1971), Billings et al. (1969) and Van Everdingen (1968), have studied the formation waters in western Canada. They found that the most important common ions in the western Canada sedimentary basin were: Cl^-, Na^+, Ca^{++} and K^+. Mg^{++}, $SO_4^=$ and HCO_3^- are less common. The amount of these ions reflects the depth of occurrence of the formation water, which can be seen in Hitchon et al. (1971, Table 1, p. 576). They also found that solid concentration is relatively low, which reflects the shallow depths of the water formation. The total dissolved solids reaches 46400 mg/l. Table 8 shows the main chemical components of formation waters from the Phillips Sandstone in the study area, which are similar to the concentrations noted by previous workers in the Cardium and Belly River Formations of the western Canadian sedimentary basin. The total solids concentration varies up to 36960 mg/l which is consistent with the shallow depth of occurrence of the formation waters. The amount of chloride, which is the most common ion, reaches 15400 mg/l in the study area. This is consistent with the amount of chloride found by Hitchon (1964) in the Belly River Formation which reaches 17000 mg/l and reflects the shallow depths of occurence of the formation waters.

The chemical analyses of samples taken from the Phillips Sandstone and Medicine Hat Sandstone indicate the presence of organic matter in the evaporated total solids. The presence of organic matter, which is essential for the methane production, along with the presence of bituminous shale in the lithology, suggest the biogenic,

Table 8. Main chemical components (mg/1) of formation waters from the Phillips Sandstone in southwestern Saskatchewan

Well Locations	Na^+, K^+	Ca^{++}	Mg^{++}	$SO_4^=$	Cl^-	$CO_3^=$	HCO_3^-	Fe (Total)	H_2S	Total Solids
7-16-2-22W3	3656	74	17	148	5560	-	259	-	-	9714
6-30-1-25W3	4401	60	27	40	6400	Trace	940	Trace	-	11868
10-24-4-26W3	1774	12	5	853	430	180	2502	Trace	-	5726
7-25-4-26W3	1836	40	11	794	1920	48	641	-	-	5290
7-16-5-26W3	2919	52	22	13	4365	Trace	487	Trace	-	7859
6-20-2-27W3	5150	88	15	379	6600	-	1420	Trace	-	13652
11-6-5-27W3	893	14	17	346	838	66	482	Trace	-	2655
6-16-5-27W3	6624	487	61	2024	9436	-	556	Trace	-	19188
7-12-6-27W3	1470	31	4	26	2150	-	283	-	-	3964
11-20-8-27W3	6907	80	28	35	10579	-	464	Trace	-	18093
11-12-2-28W3	4181	4	6	1588	650	-	8000	-	-	14429
11-24-2-28W3	3684	48	37	40	5400	30	698	Trace	-	9934
11-28-2-28W3	15100	1150	130	3690	15400	-	1490	Trace	-	36960
7-10-5-28W3	2214	6	1	683	610	-	3980	-	-	7494
10-15-6-28W3	3651	124	Trace	67	5500	247	17	Trace	-	9606
7-25-6-29W3	3406	33	17	12	4666	-	1176	Trace	-	9310

shallow, low-temperature origin of natural gas. The gas in the Bowdoin dome area and southeastern Alberta consists chiefly of methane. The methane originated from the decomposition of organic matter by biological processess at shallow depths. The organic matter is the source of CO_2 and free hydrogen, which are essential for significant methane production. Rapid deposition is a very important factor to maintain the anoxic condition necessary to produce a biogenic gas.

In the Medicine Hat Sandstone production area (Hatton Field), discrepancies in relative elevation of the formation waters reach 400 feet (122 m), which suggest migration of gas into the very permeable belt of the Medicine Hat Sand, which is located peripheral to the southern edge of the production area, against its northern pinchout prior to the main uplift of the Sweetgrass Arch (Christopher et al., 1971). Drilling to the east and southeast of the production area has been reduced as a result of lowered production in some wells caused by water invasion and the uncertainty as to southern limit of the pool (Christopher et al., 1971).

Distribution of Natural Gas

Natural gas in the Northern Great Plains, consisting chiefly of methane, was generated by biological processes at shallow depths. The presence of organic matter in the Upper Colorado sandstone bodies of the Bowdoin dome of north-central Montana, southwestern Saskatchewan and southeastern Alberta, which is the source of organic carbon suggests that the natural gas is of biogenic origin also (Rice and Shurr, 1978, 1980).

The main hydrocarbon content of the natural gas is methane (CH_4), which is usually more than 70 percent of the hydrocarbon content in commercial gas. It is also the most stable hydrocarbon and is always present as a gas because it is not condensable at temperatures and pressures within the reservoir. Ethane (C_2H_6), propane (C_3H_8), butane (C_4H_{10}), and hexane (C_6H_{14}) are other paraffin hydrocarbons which often exist in small amounts. Heptane (C_7H_{16}), octane (C_8H_{18}), and nonane (C_9H_{20}) exist in some cases.

In addition to the hydrocarbon gases there are gaseous impurities in various amounts. The main gaseous impurities in natural gas is nitrogen (N_2). Carbon dioxide (CO_2), hydrogen sulfide (H_2S) and helium (He) also exist, but helium is the only one which is commercially important. The amount of carbon dioxide and nitrogen has an inverse relation with gas inflammability and its gross heating value (Mj/m^3), by decreasing the inflammability and the gross heating value of the gas when they exist in large amounts (Levorsen, 1954).

The composition of natural gas in the study area was obtained from the gas analyses of fourteen samples which were taken from different locations. Thirteen gas analyses were done for the Phillips Sandstone and one for the Medicine Hat Sandstone (Appendix VII).

The gas analysis of the Medicine Hat Sandstone shows that methane is the main constituent at 92.15 percent of the hydrocarbons with nitrogen at 6.98 percent. Small amounts of helium (0.14 percent), carbon dioxide (0.09 percent) and ethane (0.64 percent) are present with a trace of propane but no hydrogen sulfide. The gross heating value is about 35.2 Mj/m^3, which was measured under 101.325 kPA and 15°C. The specific gravity is equal to 0.665 and the pseudo-critical pressure and temperature are 4565.94 kPA and 187.11°K respectively. The molecular weight of total gas is 16.98.

The gas analyses for the Phillips Sandstone can be seen in Appendix VII. The composition of the natural gas is mainly methane with values ranging from 84.53 to 94.87 percent. Nitrogen ranges from 4.65 percent to 15.01 percent with the exception of one well which has 28.52 percent of nitrogen and low percentage of methane of 70.26. This well is SPC Noel Senate 11-12-2-28 (Lsd 11-12-2-28W3). Small percentages of other hydrocarbons exist such as: hydrogen (0.02%), helium (0.34%), carbon dioxide (0.42%), ethane (0.64%), propane (0.01%), and butane (0.02%).

Traces of pentane, hexanes, heptanes and octanes exist in some cases. Hydrogen sulfide does not exist.

The specific gravity of the gas within the unit has a range from 0.575 to 0.686 (calculated) and from 0.583 to 0.687 (measured). The gross heating value has a range from 32.1 to 36.09 Mj/m^3, and the molecular weight of the total gas has values ranging from 16.700 to 19.878. Both the pseudo-critical pressure and temperature are low, ranging from 4460.8 to 4596 kPa and from 181.10 to 188.7°K, respectively.

The high percentage of nitrogen (28.52) at SPC Noel Senate 11-12-2-28W3 has reduced the gross heating value of the natural gas to a low of 27.5 Mj/m^3.

The presence of the carbon dioxide and the high percentage of methane in both the Medicine Hat Sandstone and Phillips Sandstone suggest that these units are prospective for natural gas. The psuedo-critical pressure and temperature are low, which means that the gas has relatively low solubility in the formation water. Helium is present in very small percentage (0.34%) which reflects the shallow depths of the gas bearing formation and its large distance above the Pre-Cambrian basement.

Hitchon (1964, 1968) studied the natural gases in western Canada, and found that methane is the chief constituent of natural gas. Ethane, propane, butane, n-butane and pentanes are common in small amounts. Nitrogen and carbon dioxide are also present along with a small percentage of helium which decreases in the shallower depths. The percentages of these components can be seen in Hitchon (1968, Table V, p. 2023), which reflects the similarity of the gas contents of the study area with other natural gas accumulations in western Canada.

The response of the geophysical well logs is affected to a large degree by the change in lithology of the succession. The combination of the spontaneous potential logs and the resistivity logs is used to define the boundaries between the units which are prospective for gas. The high negative response of the spontaneous potential curve and high resistivity response are best seen at the top of the coarsening-upward shaly sandstone and siltstone of the Phillips Sandstone and the Medicine Hat Sandstone in southwestern Saskatchewan and adjacent areas. The high SP value is indicative of a porous zone while the high resistivity value is indicative of an abundance of hydrocarbons in the porous zone (Telford et al., 1976).

Drill stem tests were taken in thirty-two wells within the study area (Appendix VIII). These tests were done for the First White-Speckled Shale, the Medicine Hat Sandstone, the Greenhorn Lime and the Phillips Sandstone. The drill stem tests for the First White-Speckled Shale and Medicine Hat Sandstone indicate showings of natural gas up to 10 Mcf/day (282.2m^3/day) at SPC NHP Arco Clearsite 7-21-9-29 well (Lsd 7-21-9-29W3) at depths between 672 and 718 m. There is also showing of gas to surface combined with little fluid recovery. These showings are located west of the eastern limit of Range 25W3 (Appendix VIII). The drill stem tests for the Greenhorn Lime indicate up to 3635 Mcf/day (102580 m^3/day) of natural gas, with a showing of gas to surface, at SPC ET AL Senate 7-12-3-29 well (Lsd 7-12-3-29W3) at depths between 780 and 805 m. The showings of natural gas from the Greenhorn Lime are mostly from the wells located west of Range 26W3. The tests for the Phillips Sandstone indicate up to 3991 Mcf/day (112634 m^3/day) of natural gas at UBR Noel Senate 11-28-2-28 well (Lsd 11-28-2-28W3) at depths between 835 and 850 m. There are also showings of gas to surface combined with little fluid recovery in some cases. Showings of natural gas from the Phillips Sandstone are located west of the eastern limit of Range 25W3.

At SPC Siebens Merryflat 7-26-6-30 well (Lsd 7-26-30W3), there are gas showings from the First White-Speckled Shale, Medicine Hat Sandstone, Greenhorn Lime and Phillips Sandstone, which gave gas flow to surface. Also, most of the wells which are located west of the Range 25W3, are showing gas from either the First White-Speckled Shale, Medicine Hat

Sandstone and Phillips Sandstone or Greenhorn Lime and Phillips Sandstone (Appendix VIII), combined with gas flow to surface in most cases. The gas showings from more than one unit in the same well makes it worthwhile to test the reservoir around that well.

HYDROCARBON POTENTIAL

General Remarks

Hydrocarbon production from the Upper Colorado Subgroup has been restricted entirely to the Medicine Hat Sandstone in the Hatton field of southwestern Saskatchewan (Christopher et al., 1971), and the Second White-Speckled Shale is considered also to be a potential gas-producing formation in the Cypress Hills of southwestern Saskatchewan (Saskatchewan Mineral Resources, 1977).

The shaly sandstone and siltstone bodies of the Upper Colorado Subgroup of southwestern Saskatchewan (Phillips Sandstone, Greenhorn Lime, and Bowdoin Sandstone) are prospective for natural gas in stratigraphic and diagenetic types of traps (Simpson, 1979a, 1979b, 1979c). The equivalent units in north-central Montana and the Second White Specks Sandstone of southeastern Alberta, are currently producing natural gas.

Reservoir Quality

Problems have arisen in the exploitation of the extensive Upper Colorado gas reservoirs in Alberta and Montana as a consequence of the high shale content of the sandstone and siltstones (Cannon 1973; Campen, 1975; Lawrence and Dzurman, 1975; Henry, 1978; Nydegger et al., 1979). The main difficulties lie in the detection of gas and the recognition of sandy layers with reduced shale content which will permit reservoir stimulation. Production comes from the thin sandstone layers, occurring in type-II elements over vertical intervals in the order of centimeters and decimeters. The porosities of these strata reach up to 29 percent, but for the most part range from 15 to 22 percent. Permeabilities, which were obtained from the core analyses, are generally less than 100 md with values of less than 1.0 md being extremely common. There are some notably high values including one of 195 md and one of 235 md (Table 7). Contrast between successive porosity-permeability determinations within coarsening-upward sequences tend to diminish gradually upwards but also shows slight increase, particularly within bioturbated lithologies. The capping lithologies in the Phillips and Medicine Hat Sandstones are calcareous concretionary layers (Kendall and Simpson, 1974; Simpson, 1979d, 1980) which form permeability barriers. The existence of strongly cemented sandstones near the top of different, coarsening-upward sequences, occupying closely comparable structural settings, suggests that the traps discovered thus far in marine Cretaceous deposits are mainly diagenetic (Simpson, 1979b).

Location of Undiscovered Gas

The stratigraphic cross-sections through the shaly sandstone and siltstone bodies of Upper Colorado Subgroup of southwestern Saskatchewan and equivalent gas-bearing strata in the Bowdoin dome area of north-central Montana and southeastern Alberta demonstrate lithologic continuity of the main units.

The commercial significance of the Second White Specks Sandstone in southeastern Alberta has been discussed by Last and Kloepfer (1973) and the Suffield Evaluation Committee (1974) as well as in two reports financed by Dome Petroleum Ltd. (Last, Kloepfer Ltd., 1973; Kloepfer and Associates, 1978). The development of the gas reserves of the Bowdoin dome region of north-central Montana was described by Nydegger _et al._, (1979). Between these two areas of production lies that part of southwestern Saskatchewan in which numerous gas showings have been reported from the Upper Colorado Sandstone Units (Fig. 20, drill stem tests, and Saskatchewan Department of Mineral Resources, 1977). The northeastern limits of Upper Colorado gas production in the Verger-Medicine Hat and Bowdoin trends lie on the northwesterly and southwesterly extensions respectively of the belt of Phillips Sandstone facies change, recognized in southwestern Saskatchewan. It is suggested that the area to the southwest of this line is also a

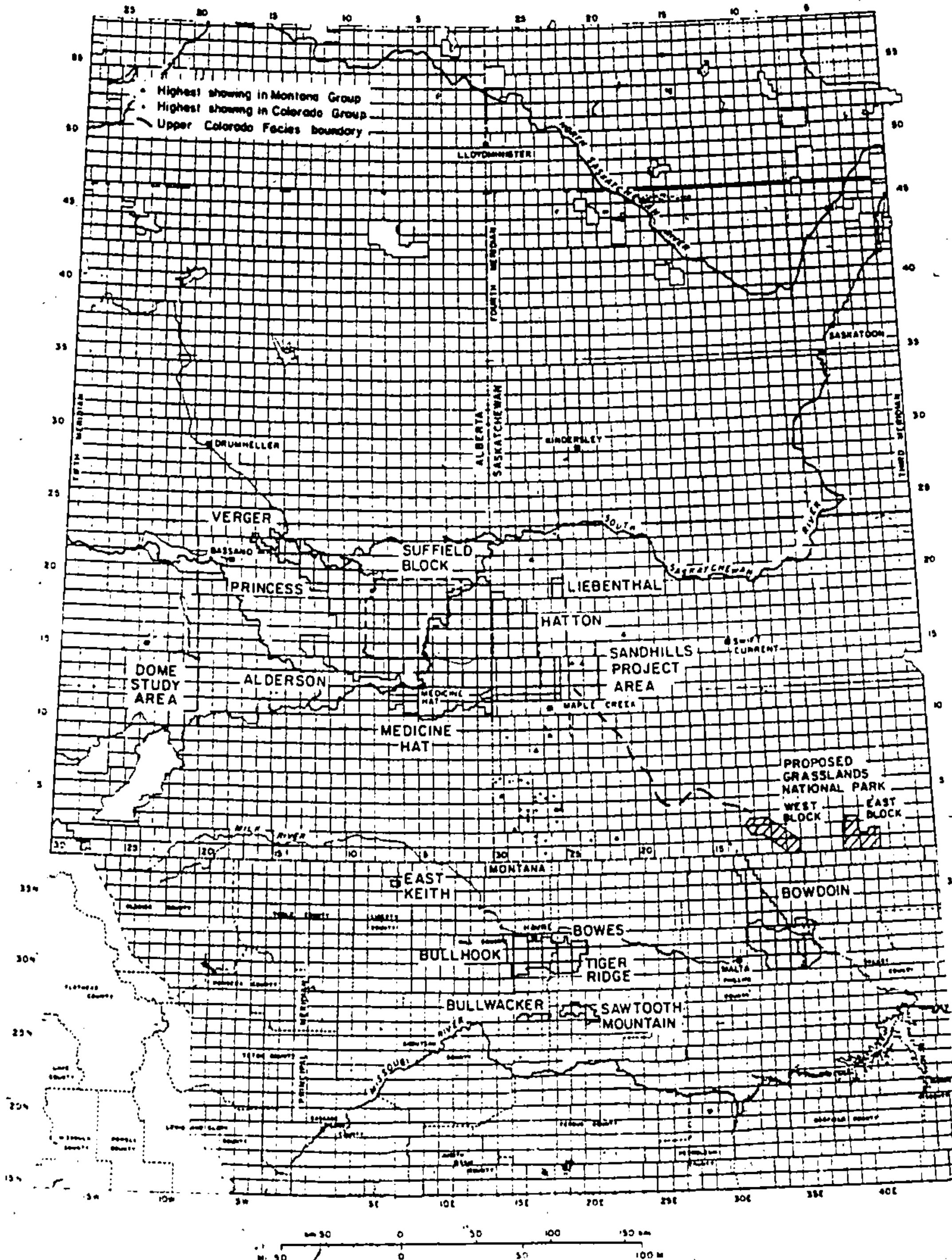


Fig. 2.0 - Main gas showings in Upper Colorado (Turonian to Santonian) succession of southwestern Saskatchewan.

prospective for gas in the Phillips Sandstone and in easterly locations in the associated Greenhorn Lime and Bowdoin Sandstone.

Likewise, detailed well-log correlation permits smaller-scale configurations of strata to be traced. This is of particular interest in regarding the area around Monchy, Saskatchewan, in that exploitation of shallow gas reserves in the Phillips Sandstone, Greenhorn Lime and Bowdoin Sandstone of neighbouring Phillips County, Montana, may initiate a southward migration of gas across the border. There are few well documented cases of lost production, caused by drainage to adjacent wells (Simpson and Katham, 1980). There has been a westward migration of gas in the Medicine Hat Sandstone from fractional sections along the Fourth Meridian, leased by Fairmont Gas Ltd. Table 9 lists the 1973 reductions of formation pressure in the recently drilled wells and attributed to production from off-setting wells in Alberta; these values are compared with pressure drops in offsetting Saskatchewan wells, in production since the mid-1960s. Corresponding pressure data are not available for the offsetting Alberta producers, many of which had been in operation since the early 1960s. It is reasonable to conclude that similar migration may take place within the other Upper Colorado sandstones.

Table 9. Pressure decrease in Medicine Hat Sandstone related to drainage of natural gas from fractional sections along Fourth Meridian, leased by Fairmont Gas Ltd.

	Pressure (Psig)		
Selected Wells	Initial	1973	Decrease
Fairmont wells in fractional sections			
8-25-15-30W3	595	508	87
8-13-16-30W3	590	432	168
8-25-18-30W3	617	430	187
Wells offsetting Fairmont property			
7-6-16-29W3	586	385	201
10-7-16-29W3	635	400	235
7-18-16-29W3	577	395	182
10-6-18-29W3	638	442	196
Second line of wells with respect to fractional sections			
6-5-16-29W3	594	374	220
6-17-16-29W3	583	384	199

CONCLUDING REMARKS

The shaly sandstone and siltstone bodies of the Upper Colorado Subgroup of southwestern Saskatchewan are prospective sources for non-associated natural gas which occurs in stratigraphic and diagenetic types of reservoirs. The lithology of the sandstone bodies in southwestern Saskatchewan shows similarity with the equivalent gas-bearing strata in the Bowdoin dome of north-central Montana and southeastern Alberta which are currently producing non-associated natural gas. They consist of fine- and very fine-grained sandstones interbedded with shale and mudstone. These units are characterized by a progressive northeasterly increase of intercalated mudstone and by the attenuation of the lowermost sandy strata of the Phillips sandstone which is characterized by two coarsening-upward cycles along with a decrease in the proportion of intercalated mudstone.

The porosity and permeability values of these units are largely affect by lithology, and they are relatively low. The permeability values are generally less than 1.0 md with some values reaching up to 100 md. The Bowdoin Sandstone and Greenhorn Lime have lower values with respect to the Martin Sandy Zone and the Phillips Sandstone, which is related to the fine-grained lithology. The average porosities of these units range from 15 to 22 percent with the lower values in the Martin Sandy Zone and Greenhorn Lime. The porosity of the Phillips Sandstone shows an upward increase related to the upward coarsening in the lithology.

Gas analyses show that methane is the main constituent of natural gas, which had a shallow, low-temperature, biogenic origin.

Water analyses show that the most common ions are: Cl^- at up to 58.4%, Na^+ and K^+ (40.8%), Ca^{++} (3%). The total solids concentration of those ions is relatively low (36960 mg/l) which is related to the shallow depth of occurrence. The presence of organic matter in the evaporated total solids suggests the biogenic origin of the gas which is supported by the presence of bituminous shale in the lithology.

Prospects for natural gas in the area from the Upper Colorado succession are supported by the numerous showing of gas reported by the Saskatchewan Department of Mineral Resources (1977). It is also supported by the drill stem tests which indicate the presence of natural gas in the Medicine Hat Sandstone, the Greenhorn Lime and the Phillips Sandstone.

The possibility exists of southwards drainage of gas across the international boundary and westwards across the Alberta border in the Phillips Sandstone, Greenhorn Lime and Bowdoin Sandstone. This is suggested by lithologic comparison with the Medicine Hat Sandstone which is penetrated by wells drilled in fractional sections along the Fourth Meridian, north of the study area in which gas pressure drops are observed. Finally it is suggested that the area to the southwest of the belt of pronounced thickness reduction and facies change in the Phillips Sandstone (Fig. 20) is a prospective source for gas in the Phillips Sandstone and in easterly locations in the associated Greenhorn Lime and Bowdoin Sandstone.

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APPENDICES

APPENDIX I

Core descriptions of selected cored sections from the Upper Colorado successions in southwestern Saskatchewan.

APPENDIX I

UBR AMOCO CONSUL 6-29-4-26
Lsd 6-29-4-26W3 KB 3088 ft. (941.2 m)

	Depth below KB	Thickness
GREENHORN LIME		
Bentonite. Light bluish grey (5B7/1), apparently grading into medium bluish grey (5B5/1), bentonitic mudstone. Horizontal lamination with obvious large biotite flakes concentrated on surfaces. Recovery about 1.5 ft. (0.45 m).	2700 ft. (841.2 m)	2.0 ft. (0.6 m)
PHILLIPS SANDSTONE		
Fine-grained sandstone and siltstone with interbedded, subordinate mudstone. Sandstone and siltstone light olive grey (5Y6/1), to olive grey (5Y4/1) as frequently graded lenses and continuous layers, rarely more than 1 cm thick, mostly in order of few mm. Mudstone dark grey (N3), non-calcareous, bituminous in places, with thickness range as for coarser material, but less frequent. Soles of relatively coarse-grained layers with numerous horizontal burrows and grooves of probable inroganic origin. *Inoceramus* values lying flat in plane of bedding. Recovery about 4 ft. (1.2 m).	2762 ft. (841.8 m)	63.0 ft. (19.2 m)

APPENDIX I - cont'd.

POC NOEL SUPREME 6-20-2-27

Lsd 6-20-2-27W3 KB 3066 ft. (934.5 m)

GREENHORN LIME	Depth Below KB	Thickness
Mudstone with interbedded fine-grained bioclastic limestone and chalk. Mudstone dark grey (N3), silty, coccolithic, bituminous in layers usually a few mm thick. Coccolithic aggregates are flakes up to a few mm in width, pale blue (5PB7/2) in colour. Limestone and chalk medium light grey (N6) to very light grey (N8); as layers ranging from less than 1 mm to about 2 cm thick, with thinner layers most abundant. Bioclastic limestone grades up into chalk, in lenses and continuous layers. Horizontal lamination and cross-lamination well developed. Pyrite concretions localized in some limestone layers. *Inoceramus* shells and debris, fish-skeletal debris common. Gradation contact with	2741 ft. (835.5 m)	3.5 ft. (1.0 m)
Mudstone. Dark grey (N3), silty coccolithic, bituminous, with very scarce lenses of bioclastic limestone and chalk. Latter lithologies commonly occurring in scattered, continuous layers, less than 1 mm thick; other data as above. Bentonitic mudstone 9.5 cm thick at about 2746.5 ft. (837.15 m). *Inoceramus* shells and debris; fish-skeletal debris.	2744.5 ft. (836.5 m)	5 ft. (1.5 m)
Bentonite. Mostly medium light grey (N6) and light bluish grey (5B7/1). Upper and lower limits fairly sharp. Horizontal lamination with conspicuous biotite flakes on surfaces.	2749.5 ft. (838.0 m)	2.0 ft. (0.6 m)
PHILLIPS SANDSTONE		
Silty mudstone. As for main lithologies of 2744.5 - 2749.5 ft. (836.5 - 838.0 m), but with generally increased silt content throughout. Calcite concretionary layer at top, up to 3 inches (7.6 cm) thick. Fairly sharp contact with	2751.5 ft. (838.67 m)	9.5 ft. (2.9 m)

POC NOEL SUPREME 6-20-2-27 - cont'd

	Depth Below KB	Thickness
Sandstone. Light olive grey (5Y6/1) to light grey (N7). Fine-grained. Quartzos, with abundant bioclastic material, silty mudstone present in discontinuous partings and continuous layers. Extensively bioturbated, with frequency of continuous sandstone layers (to 2 cm thick) increasing in basal 0.5 ft. (15.2 cm). Phosphorite pebbles and sand-size clasts scattered throughout. Calcareous fossil debris (pelecypods, coccolights) very abundant; fish-skeletal debris scattered through interval. Gradational contact with	2761.0 ft. (845.57 m)	2 ft. (0.6 m)
Sandstone. Light olive grey (5Y6/1) to light grey (N7). Fine-grained. Quartzose, micaceous; with downward-increasing silt and mud content, as discontinuous partings and continuous layers up to 2 cm thick. Sandstone in lenses and continuous layers up to 5 cm thick, mostly 2 cm or less; with low-angle cross-lamination and horizontal lamination. Tool marks and burrows on soles. Small phosphorite pebbles, granules, sand-grade clasts scattered especially; well developed *Teichichnus*; also sand-filled, tabular burrows of variable attitude to bedding. *Inoceramus* fragments and fine debris; fish-skeletal debris fairly common. Gradational contact with	2763.0 ft. (842.2 m)	12.0 ft (3.65 m)
Sandstone with interbedded siltstone and mudstone. Sandstone light olive grey (5Y6/1) to light grey (N7), quartzose, fine to very fine-grained in layers and lenses up to 2 cm thick, with sharp bases on indistinct tops frequently grading upwards into siltstone and/or mudstone; cross-lamination and horizontal lamination present. Siltstone olive grey (5Y4/1), usually horizontally laminated, less than 1 cm thick. Mudstone dark grey (N3), mostly non-calcareous, in layers up to 2 cm thick with general downward increase in abundance, lamination frequently defined by sandstone and siltstone layers less than 1 mm thick. Burrows in form of sand-filled tubes with variable orientation common. *Inoceramus* debris and fish-skeletal debris scattered. Light bluish grey (5B7/1) coccolithic specks abundant on mudstone bedding planes in basal to 10 inches (25 cm).	2775.0 ft. 845.8 m)	26 ft. (7.9 m)

UBR AMOCO BATTLE CREEK 6-16-5-27

Lsd 6-16-5-27W3 KB 3202 ft. (976.0 m)

PHILLIPS SANDSTONE	Depth Below KB	Thickness
Fine-grained sandstone and siltstone with interbedded, subordinate mudstone. Sandstone and siltstone light olive grey (5Y6/1), and olive grey (5Y4/1) as frequently graded lenses and continuous layers, rarely more than 2 cm thick, mostly in order of few mm. Bioclastic (coccolithic) limestone, medium light grey (N6) to light grey (N7), sporadically distributed. Horizontal and gently inclined laminae: some of thicker layers with chevron-like arrangement of cross-laminae sets of opposed inclinations. Mudstone dark grey (N3). Coccolithic in places, bituminous, with thickness usually few mm. Soles of relatively coarse-grained layers with short groove marks and horizontal burrows. Calcite concretionary layers 0.5 ft. thick at top of interval. *Inoceramus* valves, fish-skeletal debris of sporadic distribution. Minor bioturbation.	2803 ft. (854.5 m)	49.0 ft. (14.9 m)

SPC NOEL ET AL SENATE 11-8-2-28

Lsd 11-8-2-28W3 KB 2915 ft. (888.5 m)

GREENHORN LIME	Depth Below KB	Thickness
Mudstone with interbedded, fine-grained bioclastic limestone and chalk. Mudstone dark grey (N3), silty, calcareous, speckled and bituminous, in layers a few mm thick. Specks of coccolithic material frequently less than 1 mm width, pale blue (5PB7/2) and light bluish grey (5B7/1). Limestone and chalk medium light grey (N6) to very light grey (N8), as layers from few mm to less than 1 mm thick, both lenticular and continuous, with horizontal lamination and scarce cross-lamination, frequently graded. Pyrite concentrations elongate in plane of bedding in some carbonate layers. Pelecypod debris, fish-skeletal debris common. Gradational contact with	2500 ft. (762.0 m)	6.5 ft. (2.0 m)
Mudstone. Dark grey (N3), silty, coccolithic, bituminous, with relatively scarce calcareous intercalations. Data for latter as in 2500 - 2506.5 ft. (762.0 - 764.0 m). Bentonitic mudstone, 1.5 cm thick, at 2510.5 ft. (765.2 m). *Inoceramus* debris. Sharp contact with	2506.5 ft. (764.0 m)	6.0 ft. (1.8 m)
Bentonite. Medium grey (N5) to light bluish grey (5B7/1). Horizontal lamination with conspicuous biotite flakes on surfaces. Sharp contact with	2512.5 ft. (765.8 m)	1.0 ft. (0.3 m)
PHILLIPS SANDSTONE		
Interbedded sandstone and siltstone. Sandstone light olive grey (5Y6/1) to light grey (N7), very fine to fine-grained, quartzose, coccolithic, in layers up to 1.5 cm. thick, mostly less than 1 mm., decreasing in frequency downward, with mostly horizontal lamination. Siltstone olive grey (5Y4/1) to olive black (5Y5/1), with increasing mudstone content downwards. Frequency of interbedded sandstone increases in basal 0.5 ft. Pelecypod fragments and fish-skeletal debris. Fairly sharp, through uneven contact with	2513.5 ft. (766.1 m)	2.5 ft (0.76 m)

SPC NOEL ET AL SENATE 11-8-2-28 - cont'd.

	Depth Below KB	Thickness
Sandstone. Light olive grey (5Y6/1) and medium grey (N5) to olive grey (5Y4/1), dominantly fine-grained, muddy, calcareous, with primary stratification mostly destroyed by bioturbation. Scattered larger sand-granule and small pebble-size clasts of coalified wood and siderite. Dominant bedding feature is of irregular sandstone pods, separated by discontinuous mudstone and siltstone partings. Progressive increase in proportion of continuous siltstone and mudstone layers, a few mm thick, downwards. Horizontal, sand-filled tabular burrows and burrows with spreiten. Fairly sharp contact with	2516.0 ft. (766.9 m)	2.0 ft. (0.6 m)
Sandstone with interbedded siltstone and mudstone. Sandstone light olive grey (5Y6/1) to light grey (N7), quartzose, micaceous, in layers ranging in thickness from few mm to few cm with sharp bases and indistinct tops, frequently grading into siltstone and mudstone; cross-lamination in thicker layers, others horizontally laminated. Siltstone olive grey (5Y4/1), usually downward. Extensive burrowing gives sand admixture to finer rocks, but preserves continuity of sandstone layers. Sand-filled tubular burrow, mostly horizontal; mud-filled *Chondrites* in siltstones. Gradational contact with	2518.0 ft. (767.5 m)	6.5 ft. (2.0 m)
Sandstone with interbedded siltstone and mudstone. Main lithologies as in 2518 - 2524.5 ft. (767.5 - 769.5 m), but with reduced density of larger, sand-filled, tubular burrows. At 2533.5 5 ft. (772.2 m), 25 cm calcareous, concretionary layer with pelecypod coquinoidal layers incorporated and extensive calcite and siderite veining. Increase in proportion of sandstone from about 2545 ft. (775.7 m) downward. Coquinoidal (lecypod) beds fairly common. Also scattered pelecypod and fish-skeletal debris.	2524.5 ft. (769.5 m)	25.5 ft. (7.8 m)

UBR NOEL SENATE 11-28-2-28

Lsd (11-28-2-28W3 KB 3050 ft. (929.7 m)

GREENHORN LIME	Depth Below KB	Thickness
Mudstone with interbedded, fine-grained, bioclastic limestone and chalk. Mudstone dark grey (N3), silty in places, calcareous, speckled and slightly bituminous, in layers a few mm to 1 cm thick. Specks of coccolithic material mostly less than 1 mm. width, pale blue (5PB7/2) and light bluish grey (5B7/1), Limestone and chalk medium light grey (N6) to very light grey (N8), as layers from few mm to less than 1 mm thick, both lenticular and continuous, with horizontal lamination frequently graded. Pelecypod debris, fish-skeletal debris common. Gradational contact with	2627.0 ft. (800.7 m)	3.5 ft. (1.0 m)
Mudstone. Dark grey (N3), silty in places, coccolithic, bituminous with relatively scarce, calcareous intercalations. Data for latter as 2627 0 2630.5 ft. (800.7 - 801.8 m); increasing in abundance in basal 1 ft. Bentonite layer, 0.5 cm thick at 2634 ft. (802.86 m). Pelecypod debris, fish-skeletal debris. Gradational contact with	2630.5 ft. (801.8 m)	5.5 ft. (1.67 m)
Bentonite. Medium bluish grey (5B5/1) and light bluish grey (5B7/1) to medium light grey (N6). Numerous biotite flakes, Mostly horizontally laminated, but cross-laminated at top. Shart contact with	2636.0 ft. (803.5 m)	2.0 ft. (0.6 m)
PHILLIPS SANDSTONE		
Siltstone and silty mudstone. As in 2630.5 - 2636 ft. (801.8 - 803.5 m), but with siltstone the dominant lithology, instead of mudstone.	2638.0 ft. (804.0 m)	10.5 ft. (3.2 m)
Sandstone with interbedded siltstone and mudstone. Sandstone light olive grey (5Y6/1) to light grey (N7), fine and very fine-grained, quartzose, slightly micaceous, in layers from 1 mm or less to several cm in	2648.0 ft. (807.1 m)	7.0 ft. (2.1 m)

UBR NOEL SENATE 11-28-2-28 - cont'd.

	Depth Below KB	Thickness
thickness; thicker layers are cross-laminated, others horizontally laminated, grading upward into siltstone and/or mudstone. Siltstone olive grey (5Y4/1) to olive black (5Y2/1), usually 1 cm thick or less, horizontally laminated. Mudstone dark grey (N3), mostly non-calcareous, in layers up to 1 cm thick. Finer lithologies increase slightly in abundance downwards. Extensive burrowing. Numerous, sand-filled tubular burrows, inclined at low angles to bedding. *Chondrites* in siltstones. Gradational contact with		
Sandstone with interbedded siltstone and mudstone. As in 2648 - 2655 ft. (807.1 - 809.26 m), but with increase in proportion of finder-grained lithologies, increase in abundance of coccolithic specks, decrease in density of sand-filled tubular burrows. Scattered pelecypod and fish-skeletal debris.	2655.0 ft. (809.26 m)	35.0 ft. (10.67 m)

UBR AMOCO SENATE 10-9-3-28

Lsd 10-9-3-28W3 KB 3117 ft. (950.1 m)

GREENHORN LIME	Depth Below KB	Thickness
Mudstone with interbedded, fine-grained bioclastic limestone and chalk. Mudstone dark grey (N3), silty calcareous, speckled, and bituminous, in layer of up to 2 cm (mostly a few mm) thick. Specks of coccolithic debris, pale blue (5PB7/2) and light bluish grey (5B7/1). Limestone and chalk medium light grey (N6) to very light grey (N8), in layers ranging in thickness from few mm to less than 1 mm. Calcareous material frequently grades up into mudstone with upward-decreasing proportions of calcareous laminae. Bentonite layer 1 cm thick at 2669 ft. (813.5 m). *Inoceramus* fragments and fish-skeletal debris common. Gradational contact with	2665.0 ft. (812.3 m)	5.5 ft. (1.67 m)
Mudstone. Dark grey (N3), silty, calcareous bituminous, with relatively scarce calcareous laminae. Bentonitic mudstone, 0.5 cm thick, at 2674 ft. (815.0 m). Pelecypod and fish-skeletal debris. Gradational contact with	2670.5 ft. (814.0 m)	4.0 ft. (1.2 m)
Bentonite. Pale blue (5B6/2) to light bluish grey (5B7/1). Laminated, with bending of layering around calcareous concretion, 2.5 cm thick at about 2675 ft. (815.35 m); this incorporates bentonitic material. Sharp contact with	2674.5 ft. (815.2 m)	2.0 ft. (0.6 m)
PHILLIPS SANDSTONE		
Silty mudstone. Main lithologies as in 2670.5 - 2674.5 ft. (814.0 - 815.2 m), but with general increase in silt content. Abundant calcareous lenses and laminae in uppermost 10 ft. Gradational contact with	2676.5 ft. (815.8 m)	20.5 ft. (6.25 m)
Sandstone with interbedded siltstone and mudstone. Sandstone light olive grey (5Y6/1) to light grey (N7), very fine to fine-grained, quartzose, micaceous, in lenses and layers up to 2 cm thick. Sandstone frequently grades into siltstone and/or mudstone with varying proportions of sandy laminae. Mudstone non-calcareous in places. Plant fragments in some sandstone beds. Pelecypod fragments and fish-skeletal debris.	2697.0 ft. (822.0 m)	28.0 ft. (8.5 m)

PAN OCEAN AMOCO SENATE 11-22-4-28

Lsd 11-22-4-28W3 KB 3224 ft. (982.7 m)

GREENHORN LIME	Depth Below KB	Thickness
Mudstone. Dark grey (N3), silty in places, coccolithic, bituminous, with relatively scarce intercalations of chalk, becoming fairly common in basal 1 ft. Specks of coccolithic material less than 1 mm in width, pale blue (5PB7/2) and light bluish grey (5B7/1). Pelecypod and fish-skeletal debris. Gradational contact with	2791.0 ft. (850.7 m)	3.5 ft. (1.0 m)
Bentonite. Mainly medium bluish grey (5B5/1). Horizontally laminated, with biotite on surfaces. Sharp contact with	2794.5 ft. (851.8 m)	2.0 ft. (0.6 m)
PHILLIPS SANDSTONE		
Wiltstone with subordinate mudstone, bioclastic limestone and chalk. Siltstone olive black (5Y2/1) to olive grey (5Y4/1) in layers up to 1 cm thick, horizontally laminated. Calcareous material light grey (N7) to light olive grey (5Y4/1), in layers a few mm thick and as single laminae in siltstone and mudstone. Top 1 ft. has continuity of layering largely destroyed by burrowing. Gradational contact with	2796.5 ft. (852/4 m)	3.0 ft. (0.9 m)
Sandstone with interbedded siltstone and mudstone. Sandstone light olive grey (5Y6/1), fine and very fine-grained, quartzose, micaceous, calcareous in places, in layers from less than 1 mm to a few cm thick, with horizontal lamination and cross-lamination, grading up into siltstone and/or mudstone. Siltstone in layers generally less than 1 cm thick. Mudstone mostly calcareous, speckled in layers up to 1 cm thick. Calcareous concretionary layer, 18 cm thick at 2800 ft. (853.5 m); veined by calcite. Pelecypod and fish-skeletal debris abundant. Burrows mostly flat-lying tubular forms. *Chondrites* in siltstones.	2799.5 ft. (853.3)	51.5 ft. (15.7m)

UBR AMOCO BATTLE CK ~~6~~-17-6-28

Lsd 6-17-6-28W3 KB 3672 ft. (1119.2 m)

PHILLIPS SANDSTONE	Depth Below KB	Thickness
Sandstone with interbedded siltstone and mudstone. Sandstone light olive grey (5Y6/1) to light grey (N7), quartzose, very fine-grained in layers and lenses up to 2 cm thick, with sharp bases and indistinct tops frequently grading upwards into siltstone and/or mudstone, cross-laminated and horizontally laminated. Siltstone olive grey (5Y4/1), horizontally laminated, layers up to 1 cm thick. Mudstone dark grey (N3), variably coccolithic, in layers up to 2 cm thick, with bedding frequently defined by incorporated sandstone and siltstone laminae. Burrows common as sand-filled tubes making low angles with bedding. *Inoceramus* fragments and fish-skeletal debris scattered. Gradational contact with	3216.0 ft. (980.25 m)	37.0 ft. (11.3 m)
Siltstone with interbedded sandstone and mudstone. Main lithologies as in 3216 - 3253 ft. (980.25 - 941.5 m), but with siltstone of increased abundance. Gradational contact with	3253 ft. (991.5 m)	9.0 ft. (2.7 m)
Sandstone with interbedded siltstone and mudstone. As in 3216 - 3253 ft. (980.25 - 991.5 m)	3262 ft. (994.27 m)	9.0 ft (2.7 m)

UBR ARCO GOVENLOCK 10-19-3-29

Lsd 10-19-3-29W3 KB 3184 ft. (970.5 m)

	Depth Below KB	Thickness
GREENHORN LIME		
Mudstone with interbedded, fine-grained bioclastic limestone and chalk. Mudstone dark grey (N3), silty, calcareous, speckled and bituminous, in layers up to 2 cm (usually a few mm) thick. Specks of coccolithic debris, pale blue (5PB7/2) and light bluish grey (5B7/1). Limestone and chalk medium light grey (N6) to very light grey (N8), in layers ranging in thickness from less than 1 mm to about 1 mm. Grading of limestone up into chalk and mudstone in lenses and continuous layers. Horizontal lamination wide spread thicker layers with gently inclined laminae. Sporadic, minor bioturbation. *Inoceramus* fragments and fish-skeletal debris common. Gradational contact with	2652.0 ft. (808.3 m)	3.0 ft. (0.9 m)
Mudstone. Dark grey (N3), silty, calcareous, bituminous, with relatively scarce lenses and continuous layers of bioclastic limestone and chalk. Latter mostly as continuous layers less than 1 mm thick; other data as above. Bentonitic mudstone, 5 cm thick, at 2658.5 ft. (810.3 m). Calcite concretionary layer 1 ft. thick at 2657 ft. (809.87 m). *Inoceramus* shells and debris, fish-skeletal debris. Gradational contact with	2655 ft. (809.26 m)	5.5 ft. (1.7 m)
Bentonite. Pale blue (5B6/2) to light bluish grey (5B7/1). Horizontal lamination. Biotite flakes very abundant. Sharp contact with	2660.5 ft. (811.0 m)	2.0 ft. (0.6 m)
PHILLIPS SANDSTONE		
Silty mudstone. Main lithologies as in 2655 - 2660.5 ft. (809.26 - 811.0 m), but with general increase in silt content. Calcite concretionary layer, 8 cm thick, at interval top; similar feature, up to 20 cm thick at about 2665.5 ft (812.5 m). Gradational contact with	2662.5 ft. (811.5 m)	6.0 ft. (1.8 m)

UBR ARCO GOVENLOCK 10-19-3-29 - cont'd.

	Depth Below KB	Thickness
Siltstone with interbedded fine-grained sandstone. Siltstone dominantly muddy, olive black (5Y2/1) to olive grey (5Y4/1), in layers up to 2 cm thick. Sandstone light olive grey (5Y6/1) to light grey (N7), mostly very fine-grained, quartzose, in layers of thickness up to 1 cm. Bioclastic limestone and chalk relatively scarce, form layers up to 5 cm thick. Gradational contact with	2668.5 ft. (813.37 m)	15.5 ft. (4.7 m)
Sandstone with interbedded siltstone and mudstone. Sandstone light olive grey (5Y6/1) to light grey (N7), very fine and fine-grained, quartzose, in commonly graded layers, a few cm thick. Lenticular and wavy bedding common. Sandstone frequently grades into siltstone and/or mudstone of similar thickness. Calcite- and ? siderite-veined septaria concretion of calcite at 2685.5 ft. (818.5 m). Mudstone non-calcareous in places. Pelecypod fragments and fish-skeletal debris common. Gradational contact with .	2684.0 ft. (818.1 m)	42.0 ft. (12.8 m)
Silty mudstone. As in 2662.5 - 2668.5 ft. (811.5 - 813.37 m). Calcite filling vertical fractures in 8 cm calcareous at base.	2726.0 ft. (830.9 m)	4.0 ft. (1.2 m)

APPENDIX II

Core Analyses from Upper Colorado strata in southwestern Saskatchewan.

APPENDIX II

CORE ANALYSIS

WELL: SPC NOEL ET AL SENATE 11-8-2-28
LOCATION: LSD 11-8-2-28W3
FORMATION: SECOND WHITE SPECKS

SAMPLE NUMBER	INTERVAL REPRESENTED, FEET		HORIZ. PERM TO AIR, MILLIDARCYS	PERMEABILITY FEET	POROSITY, PER CENT	POROSITY FEET	RESIDUAL SATURATIONS, PER CENT PORE SPACE		VISUAL EXAMINATION
	DEPTH	THICK					OIL	TOTAL WATER	
	CORED INTERVAL 2500' - 2560'								
	CORE NO. 1 2500' - 2560' (REC. 57.0')								
-	2500.0-17.0	17.0	-	-	-	-	-	-	NABR
1	2517.0-17.8	0.8	8.6	6.88	20.9	16.72	3.3	64.1	FS SH/BKS
2	2517.8-18.5	0.7	23.	16.1	25.2	17.64	3.6	68.7	FS SH/BKS
3	2518.5-19.2	0.7	3.3	2.31	18.6	13.02	8.1	59.7	FS SH/BKS
4	2519.2-19.8	0.6	3.6	2.16	24.2	14.52	6.2	57.0	FS SH/BKS
5	2519.8-20.6	0.8	15.	12.0	23.9	19.12	6.3	62.3	FS
6	2520.6-21.4	0.8	7.1	5.68	26.5	21.20	1.5	74.0	FS
7	2521.4-22.2	0.8	117.	93.6	26.2	20.96	3.4	69.8	FS SH/BKS
8	2522.2-23.2	1.0	34.	34.0	25.1	25.10	2.8	68.1	FS SH/BKS
9	2523.2-24.1	0.9	29.	26.1	21.8	19.62	6.0	72.0	FS SH/BKS
10	2524.1-24.9	0.8	3.6	2.88	26.5	21.20	4.9	62.1	FS SH/BKS
11	2524.9-25.8	0.9	88.	79.2	24.8	22.32	4.4	68.7	FS SH/BKS
12	2525.8-26.6	0.8	0.2	0.16	22.5	18.00	6.7	75.6	FS SH/BKS
13	2526.6-27.6	1.0	44.	44.0	24.7	24.70	8.1	66.0	FS SH/BKS
14	2527.6-28.5	0.9	8.9	8.01	23.4	21.06	12.0	76.5	FS SH/BKS
15	2528.5-29.4	0.9	1.1	0.99	21.4	19.26	8.9	75.7	FS SH/BKS
16	2529.4-30.4	1.0	5.4	5.40	20.9	20.90	6.2	66.0	FS SH/BKS
17	2530.4-31.3	0.9	0.3	0.27	23.6	21.24	5.5	78.4	FS SH/BKS
18	2531.3-32.1	0.8	5.1	4.08	16.4	13.12	6.7	62.1	FS SH/BKS
-	2532.1-33.4	1.3	-	-	-	-	-	-	SH
19	2533.4-34.1	0.7	19.	13.3	22.5	15.75	4.9	62.2	FS SH/BKS
-	2534.1-35.2	1.1	-	-	-	-	-	-	DENSE
20	2535.2-36.2	1.0	0.7	0.70	19.0	19.00	6.3	77.7	FS SH/BKS
21	2536.2-37.0	0.8	22.	17.6	24.3	19.44	6.2	63.1	FS SH/BKS
22	2537.0-38.0	1.0	1.6	1.60	24.0	24.00	0.8	65.8	FS

APPENDIX II - Cont'd.

WELL: SPC NOEL ET AL SENATE 11-8-2-28 - cont'd

SAMPLE NUMBER	INTERVAL REPRESENTED, FEET		HORIZ. PERM TO AIR, MILLIDARCYS	PERMEABILITY FEET	POROSITY, PER CENT	POROSITY FEET	RESIDUAL SATURATIONS, PER CENT PORE SPACE		VISUAL EXAMINATION
	DEPTH	THICK					OIL	TOTAL WATER	
	CORE NO. 1 (Cont'd)								
23	2538.0-39.0	1.0	13.	13.0	24.1	24.10	3.7	78.4	FS SH/BKS
24	2539.0-39.9	0.9	15.	13.5	21.3	19.17	5.2	72.7	FS SH/BKS
25	2539.9-41.1	1.2	0.6	0.72	19.1	22.92	2.1	65.4	FS SH/BKS
26	2541.1-42.0	0.9	1.0	0.90	20.3	18.27	6.4	75.9	FS
27	2542.0-43.1	1.1	3.3	3.63	22.1	24.31	6.8	76.9	FS SH/BKS
28	2543.1-44.1	1.0	9.8	9.80	20.2	22.20	7.4	81.2	FS SH/BKS
29	2544.1-45.1	1.0	1.6	1.60	21.1	21.10	5.2	77.7	FS SH/BKS
30	2545.1-46.1	1.0	0.6	0.60	20.9	20.90	1.0	75.6	FS SH/BKS
31	2546.1-47.1	1.0	1.6	1.60	21.1	21.10	2.8	80.6	FS SH/BKS
32	2547.1-48.0	0.9	5.1	4.59	22.1	19.89	8.6	72.3	FS SH/BKS
33	2548.0-48.9	0.9	18.	16.2	24.1	21.69	2.1	65.6	FS SH/BKS
34	2548.9-49.8	0.9	8.3	7.47	21.8	19.62	5.0	78.0	FS SH/BKS
35	2549.8-50.7	0.9	2.4	2.16	20.5	18.45	2.9	82.9	FS SH/BKS
36	2550.7-51.7	1.0	8.0	8.00	18.8	18.80	8.0	69.1	FS SH/BKS
37	2551.7-52.6	0.9	18.	16.2	22.7	20.43	4.0	77.1	FS SH/BKS
38	2552.6-53.5	0.9	3.3	2.97	22.0	19.80	5.0	75.0	FS SH/BKS
39	2553.5-54.4	0.9	3.9	3.51	24.2	21.78	4.5	71.9	FS SH/BKS
40	2554.4-55.2	0.8	6.0	4.80	20.7	16.56	5.3	76.8	FS SH/BKS
41	2555.2-56.1	0.9	-0.1	-0.1	19.8	17.82	5.6	73.2	FS SH/BKS
-	2556.1-57.0	0.9	-	-	-	-	-	-	SH
-	2557.0-60.0	3.0	-	-	-	-	-	-	LOST CORE.

APPENDIX II - Cont'd.

WELL: UBR NOEL SENATE 11-28-2-28
LOCATION: LSD 11-28-2-28W3
FORMATION: SECOND WHITE SPECKS

SAMPLE NUMBER	INTERVAL REPRESENTED, FEET		HORIZ. PERM TO AIR, MILLIDARCYS	PERMEABILITY FEET	POROSITY, PER CENT	POROSITY FEET	RESIDUAL SATURATIONS, PER CENT PORE SPACE		VISUAL EXAMINATION
	DEPTH	THICK					OIL	TOTAL WATER	
CORED INTERVAL	2627' - 2689.4								
CORE NO. 1	2627' - 2664' (REC. 37.0')								
-	2627.0-27.4	0.4	-	-	-	-	-	-	SH
A	2627.4-28.1	0.7	0.8	0.56	11.9	8.33	10.1	80.7	SEE NOTE
B	2628.1-28.9	0.8	0.3	0.24	14.6	11.68	17.1	76.0	SEE NOTE
C	2628.9-29.7	0.8	0.4	0.32	16.2	12.96	23.5	71.6	SEE
-	2629.7-32.7	3.0	-	-	-	-	-	-	SH
D	2632.7-33.2	0.5	-0.1	-	14.1	7.05	24.1	64.5	SEE NOTE
-	2633.2-37.5	4.3	-	-	-	-	-	-	SH
E	2637.5-38.2	0.7	0.6	0.42	6.8	4.76	22.1	54.4	SEE NOTE
F	2638.2-38.8	0.6	-0.1	-	10.0	6.00	21.0	71.0	SEE NOTE
-	2638.8-39.2	0.4	-	-	-	-	-	-	SH
G	2639.2-39.9	0.7	-0.1	-	16.7	11.69	23.4	69.5	SEE NOTE
-	2639.9-41.3	1.4	-	-	-	-	-	-	SH
H	2641.3-42.1	0.8	1.6	1.08	14.1	11.28	26.2	60.3	SEE NOTE
-	2642.1-42.8	0.7	-	-	-	-	-	-	SH
I	2642.8-43.7	0.9	-0.1	-	15.2	13.68	17.8	50.0	SEE NOTE
-	2643.7-45.2	1.5	-	-	-	-	-	-	SH
J	2645.2-46.0	0.8	0.7	0.56	15.9	12.72	11.9	66.0	SEE NOTE
K	2646.0-46.7	0.7	1.3	0.91	15.8	11.06	21.5	50.0	SEE NOTE
-	2646.7-48.0	1.3	-	-	-	-	-	-	SH

NOTE: INTERBEDDED SHALE AND SILTSTONE. SILTSTONE IS NOT STAINED.

WELL: UBR NOEL SENATE 11-28-2-28 - cont'd APPENDIX II - cont'd.

SAMPLE NUMBER	INTERVAL REPRESENTED, FEET		HORIZ. PERM. TO AIR, MILLIDARCYS	PERMEABILITY FEET	POROSITY, PER CENT	POROSITY FEET	RESIDUAL SATURATIONS, PER CENT PORE SPACE		VISUAL EXAMINATION
	DEPTH	THICK					OIL	TOTAL WATER	
CORE NO. 1 (Cont'd)									
1	2648.0-48.6	0.6	90.	54.0	22.8	13.68	1.8	31.1	FS SHY 60% SAND
2	2648.6-49.2	0.6	105.	63.0	19.7	11.82	0.0	32.5	FS SHY 90% SAND
3	2649.2-50.0	0.8	44.	35.2	24.4	19.52	2.0	46.7	FS SHY 80% SAND
4	2650.0-50.9	0.9	39.	35.1	22.7	20.43	3.1	48.0	FS SHY 80% SAND
5	2650.9-51.8	0.9	54.	48.6	19.5	17.55	1.0	46.7	FS SHY 75% SAND
6	2651.8-52.6	0.8	29.	23.2	26.7	21.36	Trace	40.8	FS SHY 75% SAND
7	2652.6-53.5	0.9	31.	27.9	23.2	20.88	3.9	47.0	FS SHY 65% SAND
8	2653.5-54.3	0.8	12.	9.6	20.9	16.72	2.4	50.2	FS SHY 60% SAND
9	2654.3-55.2	0.9	9.8	8.82	24.7	22.23	3.6	38.5	FS SHY 60% SAND
10	2655.2-56.0	0.8	39.	31.2	22.3	17.84	3.1	51.6	FS SHY 50% SAND
11	2656.0-56.9	0.9	235.	211.5	25.7	23.13	3.5	45.1	FS SHY 55% SAND
12	2656.9-57.7	0.8	36.	28.8	24.2	19.36	3.7	54.5	FS SHY 55% SAND
13	2657.7-58.6	0.9	41.	36.9	22.3	20.07	2.2	34.5	FS SHY 60% SAND
14	2658.6-59.1	0.5	39.	19.5	21.4	10.70	2.3	47.7	FS SHY 65% SAND
15	2659.1-60.1	1.0	-0.1	-0.1	19.5	19.50	5.1	82.6	FS SHY 10% SAND
16	2660.1-60.9	0.8	-0.1	-0.1	14.7	11.76	4.1	83.7	FS SHY 10% SAND
17	2660.9-61.9	1.0	0.1	0.10	22.7	22.70	4.4	64.3	FS SHY 5% SAND
18	2661.9-62.9	1.0	41.	41.0	23.7	23.70	3.4	65.4	FS SHY 30% SAND
19	2662.9-64.0	1.1	5.7	6.27	26.2	28.82	Trace	51.9	FS SHY 35% SAND
CORE NO. 2 2664' - 2689.4 (REC. 25.4')									
20	2664.0-64.6	0.6	0.1	0.06	20.0	12.00	5.0	79.5	FS SHY 10% SAND
21	2664.6-64.8	0.2	6.0	1.20	24.5	4.90	Trace	53.9	FS 100% SAND
22	2664.8-65.8	1.0	0.1	0.10	20.6	20.60	3.9	80.1	FS SHY 15% SAND
23	2665.8-66.7	0.9	3.0	2.70	26.3	23.67	0.8	46.0	FS SHY 30% SAND
24	2666.7-66.9	0.2	1.4	0.28	27.9	5.58	Trace	45.5	FS SHY 90% SAND
25	2666.9-67.6	0.7	2.4	1.68	23.0	16.10	Trace	61.3	FS SHY 30% SAND
26	2667.6-68.4	0.8	3.3	2.64	27.1	21.68	Trace	50.9	FS SHY 30% SAND
27	2668.4-69.4	1.0	0.6	0.60	22.5	22.50	3.6	86.2	FS SHY 25% SAND
28	2669.4-70.4	1.0	0.3	0.30	22.1	22.10	4.5	80.1	FS SHY 15% SAND
29	2670.4-71.4	1.0	1.2	1.20	16.1	16.10	5.0	75.2	FS SHY 25% SAND
30	2671.4-72.4	1.0	-0.1	-0.1	20.8	20.80	6.7	82.7	FS SHY 20% SAND
31	2672.4-73.4	1.0	1.8	1.80	21.3	21.30	4.7	76.6	FS SHY 20% SAND

APPENDIX II - cont'd.

WELL: UBR NOEL SENATE 11-28-2-28 - cont'd

SAMPLE NUMBER	INTERVAL REPRESENTED, FEET		HORIZ. PERM TO AIR, MILLIDARCYS	PERMEABILITY FEET	POROSITY, PER CENT	POROSITY FEET	RESIDUAL SATURATIONS, PER CENT PORE SPACE		VISUAL EXAMINATION
	DEPTH	THICK					OIL	TOTAL WATER	
CORE NO. 2 (Cont'd)									
32	2673.4-74.1	0.7	0.7	0.49	21.6	15.12	5.1	82.4	FS SHY 20% SAND
33	2674.1-74.6	0.5	1.8	0.90	22.0	11.00	0.0	55.5	FS SHY 25% SAND
34	2674.6-75.5	0.9	24.	21.6	23.8	21.42	3.4	74.4	FS SHY 25% SAND
35	2675.5-76.3	0.8	0.8	0.64	15.0	12.00	4.0	77.3	FS SHY 40% SAND
36	2676.3-77.2	0.9	14.	12.6	14.7	13.23	3.4	64.6	FS SHY 30% SAND
37	2677.2-78.2	1.0	5.1	5.10	25.2	25.20	2.4	60.7	FS SHY 25% SAND
38	2678.2-79.1	0.9	8.3	7.47	21.0	18.90	3.8	63.3	FS SHY [illegible] SAND
39	2679.1-80.1	1.0	0.8	0.80	18.5	18.50	Trace	67.0	FS SHY 20% SAND
40	2680.1-81.2	1.1	11.	12.1	21.6	23.76	Trace	58.8	FS SHY 35% SAND
41	2681.2-82.0	0.8	3.7	2.96	18.8	15.04	3.2	69.7	FS SHY 30% SAND
42	2682.0-83.0	1.0	1.0	1.00	21.4	21.40	4.2	66.8	FS SHY 30% SAND
43	2683.0-83.8	0.8	12.	9.6	19.7	15.76	3.0	65.0	FS SHY 25% SAND
44	2683.8-84.8	1.0	1.7	1.70	16.7	16.70	3.6	73.1	FS SHY 35% SAND
45	2684.8-85.9	1.1	0.3	0.33	19.0	20.90	3.2	71.1	FS SHY 30% SAND
46	2685.9-86.9	1.0	0.7	0.70	16.5	16.50	4.8	75.8	FS SHY 30% SAND
47	2686.9-87.9	1.0	3.3	3.30	18.5	18.50	4.3	61.6	FS SHY 25% SAND
48	2687.9-88.6	0.7	0.6	0.42	17.4	12.18	6.9	82.8	FS SHY 20% SAND
49	2688.6-89.4	0.8	7.7	6.16	21.8	17.44	1.8	60.6	FS SHY 35% SAND

WELL: UBR AMOCO SENATE 10-9-3-28
LOCATION: LSD 10-9-3-28W3
FORMATION: SECOND WHITE SPECKS

SAMPLE NUMBER	INTERVAL REPRESENTED, FEET		HORIZ. PERM TO AIR, MILLIDARCYS	PERMEABILITY FEET	POROSITY PER CENT	POROSITY FEET	RESIDUAL SATURATIONS, PER CENT PORE SPACE		VISUAL EXAMINATION
	DEPTH	THICK					OIL	TOTAL WATER	
CORED INTERVAL 2665' - 2725'									
CORE NO. 1 2665' - 2725' (REC. 60.0')									
-	2665.0-95.0	30.0	-	-	-	-	-	-	NABR
1	2695.0-95.7	0.7	0.5	0.35	21.8	15.26	11.9	78.0	FS SHY 5% SAND
2	2695.7-96.5	0.8	1.1	0.88	19.4	15.52	20.1	62.4	FS SHY 20% SAND
3	2696.5-97.2	0.7	1.0	0.70	18.7	13.09	4.8	55.6	FS SHY 15% SAND
4	2697.2-97.9	0.7	12.0	8.40	17.6	12.32	7.4	60.8	FS SHY 50% SAND
5	2697.9-98.8	0.9	3.3	2.97	23.5	21.15	2.1	46.4	FS SHY 10% SAND
6	2698.8-99.5	0.7	1.2	0.84	14.4	10.08	10.4	43.8	FS SHY 30% SAND
7	2699.5-00.2	0.7	29.0	20.30	22.0	15.40	9.1	63.6	FS SHY 30% SAND
8	2700.2-01.0	0.8	0.5	0.40	19.1	15.28	6.8	59.2	FS SHY 20% SAND
9	2701.0-01.8	0.8	1.6	1.28	22.2	17.76	6.8	70.7	FS SHY 15% SAND
10	2701.8-02.6	0.8	1.8	1.44	25.9	20.72	4.2	52.9	FS SHY 20% SAND
11	2702.6-03.4	0.8	0.5	0.40	21.6	17.28	5.1	63.0	FS SHY 35% SAND
12	2703.4-04.2	0.8	0.7	0.56	23.4	18.72	3.8	66.2	FS SHY 20% SAND
13	2704.2-04.9	0.7	0.3	0.21	10.9	7.63	5.5	54.1	FS SHY 15% SAND
14	2704.9-05.6	0.7	0.7	0.49	19.5	13.65	4.6	73.8	FS SHY 30% SAND
15	2705.6-06.4	0.8	2.4	1.92	20.4	16.32	5.4	68.1	FS SHY 25% SAND
16	2706.4-07.2	0.8	1.8	1.44	17.5	14.00	5.1	74.3	FS SHY 20% SAND
17	2707.2-08.0	0.8	0.5	0.40	21.9	17.52	5.9	55.3	FS SHY 30% SAND
18	2708.0-08.8	0.8	0.5	0.40	19.0	15.20	3.2	82.6	FS SHY 35% SAND
19	2708.8-09.6	0.8	3.3	2.64	9.9	7.92	0.0	45.5	FS SHY 40% SAND
20	2709.6-10.4	0.8	0.6	0.48	15.4	12.32	3.2	50.6	FS SHY 50% SAND
21	2710.4-11.2	0.8	0.5	0.40	16.5	13.20	3.6	80.0	FS SHY 40% SAND
22	2711.2-12.0	0.8	0.9	0.72	19.3	15.44	4.7	71.0	FS SHY 50% SAND
23	2712.0-12.7	0.7	0.8	0.56	22.9	16.03	3.9	51.5	FS SHY 35% SAND
24	2712.7-13.5	0.8	1.0	0.80	16.2	12.96	8.0	77.8	FS SHY 40% SAND
25	2713.5-14.3	0.8	2.9	2.32	25.9	20.72	4.6	45.9	FS SHY 25% SAND

APPENDIX II - cont'd.

WELL: UBR AMOCO SENATE 10-9-3-28 - cont'd

SAMPLE NUMBER	INTERVAL REPRESENTED, FEET		HORIZ. PERM TO AIR, MILLIDARCYS	PERMEABILITY FEET	POROSITY, PER CENT	POROSITY FEET	RESIDUAL SATURATIONS, PER CENT PORE SPACE		VISUAL EXAMINATION
	DEPTH	THICK					OIL	TOTAL WATER	
CORE NO. 1 (Cont'd)									
26	2714.3-15.0	0.7	2.6	1.82	20.9	14.63	5.3	57.4	FS SHY 30% SAND
27	2715.0-15.7	0.7	3.9	2.73	20.5	14.35	5.4	66.8	FS SHY 20% SAND
28	2715.7-15.9	0.2	3.0	0.60	25.6	5.12	Trace	50.0	FS SHY 80% SAND
29	2715.9-16.7	0.8	7.4	5.92	21.9	17.52	2.7	67.6	FS SHY 25% SAND
30	2716.7-17.6	0.9	4.2	3.78	24.6	22.12	4.5	48.0	FS SHY 25% SAND
31	2717.6-18.5	0.9	3.0	2.70	25.2	22.68	4.4	53.2	FS SHY 20% SAND
32	2718.5-19.3	0.8	0.7	0.56	18.1	14.48	5.0	62.4	FS SHY 25% SAND
33	2719.3-20.3	1.0	31.0	31.00	24.0	24.00	3.3	37.5	FS SHY 30% SAND
34	2720.3-21.2	0.9	7.4	6.66	17.2	15.48	5.2	47.1	FS SHY 30% SAND
35	2721.2-22.2	1.0	0.2	0.20	16.1	16.10	8.1	78.3	FS SHY 30% SAND
36	2722.2-23.1	0.9	1.4	1.26	22.4	20.16	4.0	55.8	FS SHY 25% SAND
37	2723.1-24.1	1.0	1.4	1.40	17.4	17.40	4.0	70.1	FS SHY 20% SAND
38	2724.1-25.0	0.9	2.0	1.80	23.8	21.42	3.8	56.3	FS SHY 10% SAND

WELL: UBR AMOCO BATTLE CK 6-17-6-28
LOCATION: LSD 6-17-6-28W3
FORMATION: SECOND WHITE SPECKS

APPENDIX II - cont'd

SAMPLE NUMBER	INTERVAL REPRESENTED, FEET		HORIZ. PERM TO AIR, MILLIDARCYS	PERMEABILITY FEET	POROSITY, PER CENT	POROSITY FEET	RESIDUAL SATURATIONS, PER CENT PORE SPACE		SAND	VISUAL EXAMINATION
	DEPTH	THICK					OIL	TOTAL WATER		
CORED INTERVAL 3216' - 3271'										
CORE NO. 1 3216' - 3241' (REC. 24.6') (5 BOXES)										
1	3216.0-16.6	0.6	17.60	10.56	25.6	15.36	6.2	63.8	50	FS SHY
-	3216.6-16.7	0.1	-	-	-	-	-	-	0	SH
2	3216.7-17.3	0.6	47.50	28.50	27.2	16.32	5.8	64.0	40	FS SH/BKS
-	3217.3-17.5	0.2	-	-	-	-	-	-	0	SH
3	3217.5-17.9	0.4	6.59	2.64	24.4	9.76	2.9	70.1	80	FS SH/BKS
4	3217.9-18.4	0.5	55.80	27.90	29.7	14.85	7.4	49.7	50	FS SH/BKS
5	3218.4-19.0	0.6	20.20	12.12	22.9	13.74	8.0	72.2	40	FS SH/BKS
6	3219.0-19.4	0.4	64.00	25.60	24.8	9.92	5.7	64.7	50	FS SH/BKS
7	3219.4-19.8	0.4	1.06	0.42	22.1	8.84	5.7	66.2	60	FS SH/BKS
8	3219.8-20.2	0.4	4.26	1.70	26.2	10.48	4.7	58.9	50	FS SHY
-	3220.2-20.3	0.1	-	-	-	-	-	-	0	SH
9	3220.3-20.9	0.6	NP	-	24.2	14.52	6.0	65.1	60	FS SHY
10	3220.9-21.4	0.5	3.21	1.60	23.8	11.90	6.0	62.3	40	FS SHY
11	3221.4-22.0	0.6	46.40	27.84	24.5	14.70	5.0	59.6	50	FS SHY
12	3222.0-22.6	0.6	4.20	2.52	23.1	13.86	5.6	69.6	40	FS SH/BKS
13	3222.6-23.4	0.8	16.70	13.36	26.4	21.12	4.7	56.5	40	FS SHY
14	3223.4-24.2	0.8	NP	-	23.6	18.88	6.9	56.8	30	SH SAND/BKS
15	3224.2-24.9	0.7	195.00	136.50	24.1	16.87	6.0	61.6	80	FS SHY
16	3224.9-25.6	0.7	8.79	6.15	24.4	17.08	5.8	64.7	20	SH SAND/BKS
-	3225.6-26.5	0.9	-	-	-	-	-	-	5	SH SAND LENSES
17	3226.5-27.2	0.7	1.60	1.12	21.6	15.12	13.6	73.5	10	SH SAND/BKS
18	3227.2-28.1	0.9	0.76	0.68	21.9	19.71	8.4	79.5	10	SH SAND/BKS
-	3228.1-29.0	0.9	-	-	-	-	-	-	5	SH SAND LENSES
19	3229.0-29.5	0.5	NP	-	25.6	12.80	10.7	67.2	10	SH SAND/BKS
-	3229.5-29.8	0.3	-	-	-	-	-	-	5	SH SAND LENSES
20	3229.8-30.6	0.8	NP	-	21.5	17.20	11.1	74.0	10	SH SAND/BKS
-	3230.6-33.0	2.4	-	-	-	-	-	-	5	SH SAND LENSES

WELL: UBR AMOCO BATTLE CK 6-17-6-28 - cont'd

SAMPLE NUMBER	INTERVAL REPRESENTED, FEET		HORIZ. PERM TO AIR, MILLIDARCYS	PERMEABILITY FEET	POROSITY, PER CENT	POROSITY FEET	RESIDUAL SATURATIONS, PER CENT PORE SPACE		% SAND	VISUAL EXAMINATION
	DEPTH	THICK					OIL	TOTAL WATER		
CORE NO. 1 (Cont'd)										
21	3233.0-33.9	0.9	NP	-	22.5	20.25	10.6	68.6	10	SH SAND/BKS
-	3233.9-34.2	0.3	-	-	-	-	-	-	0	SH
22	3234.2-35.0	0.8	0.59	0.47	20.3	16.24	8.4	82.2	30	SH SAND/BKS
23	3235.0-35.7	0.7	4.39	3.07	24.1	16.87	5.9	61.4	20	SH SAND/BKS
24	3235.7-36.4	0.7	NP	-	22.5	15.75	7.5	71.9	40	FS SHY
25	3236.4-37.2	0.8	NP	-	21.1	16.88	7.1	71.3	30	SH SAND/BKS
26	3237.2-37.9	0.7	NP	-	24.2	16.94	6.7	61.9	20	SH SAND/BKS
27	3237.9-38.7	0.8	NP	-	25.9	20.72	7.0	60.4	30	SH SAND/BKS
28	3238.7-39.3	0.6	37.40	22.44	24.5	14.70	6.0	61.7	20	SH SAND/BKS
29	3239.3-40.1	0.8	NP	-	26.1	20.88	7.6	60.8	30	SH SAND/BKS
30	3240.1-40.6	0.5	NP	-	22.4	11.20	8.2	66.2	40	FS SHY.
-	3240.6-41.0	0.4	-	-	-	-	-	-	-	LOST CORE.
CORE NO. 2	3241' - 3271' (REC. 30') (7 BOXES)									
31	3241.0-41.6	0.6	1.87	1.12	29.2	17.52	4.3	53.6	60	FS SHY
32	3241.6-42.4	0.8	NP	-	26.1	20.88	7.8	68.4	50	FS SHY
33	3242.4-43.4	1.0	NP	-	27.3	27.30	5.9	58.3	30	SH SAND/BKS
-	3243.4-43.9	0.5	-	-	-	-	-	-	5	SH SAND LENSES
34	3243.9-44.8	0.9	NP	-	22.8	20.52	12.2	76.9	20	SH SAND/BKS
-	3244.8-45.1	0.3	-	-	-	-	-	-	5	SH SAND LENSES
35	3245.1-45.9	0.8	NP	-	22.9	18.32	12.8	73.0	20	SH SAND/BKS
36	3245.9-46.7	0.8	NP	-	21.4	17.12	8.8	71.7	10	SH SAND/BKS
37	3246.7-47.1	0.4	2.23	0.89	24.9	9.96	3.7	64.2	30	SH SAND/BKS
38	3247.1-48.1	1.0	NP	-	23.2	23.20	7.2	72.0	30	SH SAND/BKS
39	3248.1-49.1	1.0	6.16	6.16	25.1	25.10	3.6	62.7	30	SH SAND/BKS
40	3249.1-50.1	1.0	NP	-	23.9	23.90	7.0	74.0	20	SH SAND/BKS
41	3250.1-51.1	1.0	NP	-	22.5	22.50	8.3	76.5	10	SH SAND/BKS
42	3251.1-52.1	1.0	NP	-	25.6	25.60	6.3	65.3	20	SH SAND/BKS
43	3252.1-53.1	1.0	NP	-	27.0	27.00	4.6	64.7	30	SH AND/BKS
44	3253.1-53.9	0.8	NP	-	25.6	20.48	5.6	63.9	40	SH SAND/BKS
45	3253.9-54.6	0.7	27.30	19.11	21.9	15.33	9.3	76.6	30	SH SAND/BKS
46	3254.6-55.2	0.6	NP	-	23.5	14.10	6.4	72.6	20	SH SAND/BKS
-	3255.2-55.7	0.5	-	-	-	-	-	-	5	SH SAND LENSES

WELL: UBR AMOCO BATTLE CK 6-17-6-28 - cont'd

SAMPLE NUMBER	INTERVAL REPRESENTED, FEET		HORIZ. PERM TO AIR, MILLIDARCYS	PERMEABILITY FEET	POROSITY, PER CENT	POROSITY FEET	RESIDUAL SATURATIONS, PER CENT PORE SPACE		% SAND	VISUAL EXAMINATION
	DEPTH	THICK					OIL	TOTAL WATER		
CORE NO. 2 (Cont'd)										
47	3255.7-56.4	0.7	NP	-	22.5	15.75	6.5	70.7	20	SH SAND/BKS
-	3256.4-61.3	4.9	-	-	-	-	-	-	5	SH SAND LENSES
48	3261.3-62.1	0.8	NP	-	22.2	17.76	5.9	72.4	10	SH SAND/BKS
-	3262.1-62.8	0.7	-	-	-	-	-	-	5	SH SAND LENSES
49	3262.8-63.7	0.9	NP	-	22.9	20.61	5.8	81.5	10	SH SAND/BKS
-	3263.7-63.9	0.2	-	-	-	-	-	-	0	SH
50	3263.9-64.4	0.5	NP	-	20.3	10.15	8.3	82.0	10	SH SAND/BKS
-	3264.4-64.9	0.5	-	-	-	-	-	-	5	SH SAND LENSES
51	3264.9-65.9	1.0	NP	-	19.9	19.90	7.6	81.1	10	SH SAND/BKS
52	3265.9-66.8	0.9	NP	-	20.4	18.36	9.3	84.6	10	SH SAND/BKS
-	3266.8-71.0	4.2	-	-	-	-	-	-	5	SH SAND LENSES

APPENDIX II - cont'd.

WELL: UBR ARCAN GOVENLOCK 10-19-3-29
LOCATION: LSD 10-19-3-29
FORMATION: SECOND WHITE SPECKS

SAMPLE NUMBER	INTERVAL REPRESENTED, FEET		HORIZ. PERM TO AIR, MILLIDARCYS	PERMEABILITY FEET	POROSITY PER CENT	POROSITY FEET	RESIDUAL SATURATIONS, PER CENT PORE SPACE		VISUAL EXAMINATION
	DEPTH	THICK					OIL	TOTAL WATER	
CORED INTERVAL 2652' - 2732'									
CORE NO. 1 2652' - 2672' (REC. 19.6')									
1	2652.0-54.6	2.6	0.3	0.78	16.8	43.68	14.3	81.0	SEE NOTE
2	2654.6-57.0	2.4	-0.1	-0.1	23.5	56.40	11.9	83.4	SEE NOTE
-	2657.0-57.9	0.9	-	-	-	-	-	-	DENSE
3	2657.9-60.6	2.7	-0.1	-0.1	22.4	60.48	16.5	79.9	SEE NOTE
-	2660.6-62.9	2.3	-	-	-	-	-	-	DENSE
4	2662.9-64.8	1.9	0.2	0.38	13.4	25.46	18.7	73.1	SEE NOTE
5	2664.8-66.8	2.0	-0.1	-0.1	19.4	38.80	25.3	70.1	SEE NOTE
6	2666.8-69.7	2.9	-0.1	-0.1	19.8	57.42	15.7	74.7	SEE NOTE
7	2669.7-71.6	1.9	0.1	0.19	20.3	38.57	10.8	66.5	SEE NOTE
-	2671.6-72.0	0.4	-	-	-	-	-	-	LOST CORE.
CORE NO. 2 2672' - 2732' (REC. 53.0')									
8	2672.0-73.6	1.6	-0.1	-0.1	21.8	34.88	15.6	73.9	SEE NOTE
9	2673.6-75.5	1.9	-0.1	-0.1	20.7	39.33	16.4	75.8	SEE NOTE
10	2675.5-77.1	1.6	-0.1	-0.1	21.2	33.92	13.2	74.5	SEE NOTE
11	2677.1-78.8	1.7	0.3	0.51	23.0	39.10	17.0	72.2	SEE NOTE
12	2678.8-80.4	1.6	-0.1	-0.1	22.1	35.36	16.3	76.9	SEE NOTE
13	2680.4-82.0	1.6	-0.1	-0.1	22.6	36.16	13.7	78.3	SEE NOTE
14	2682.0-83.7	1.7	-0.1	-0.1	21.2	36.04	13.7	78.8	FS SHY 10% SAND
15	2683.7-84.0	0.3	7.1	2.13	22.1	6.63	0.9	72.4	FS SHY 15% SAND
16	2684.0-85.0	1.0	4.5	4.50	25.1	25.10	3.6	76.5	FS SHY 25% SAND
17	2685.0-85.6	0.6	0.6	0.36	28.0	16.80	0.7	59.6	FS SHY 25% SAND
-	2685.6-85.9	0.3	-	-	-	-	-	-	SH
18	2685.9-86.7	0.8	0.4	0.32	24.2	19.36	5.4	84.3	FS SHY 20% SAND
19	2686.7-87.4	0.7	0.6	0.42	21.9	15.33	2.7	71.7	FS SHY 30% SAND

APPENDIX II - cont'd.

WELL: UBR ARCAN GOVENLOCK -10-19-3-29 - cont'd

SAMPLE NUMBER	INTERVAL REPRESENTED, FEET		HORIZ. PERM TO AIR, MILLIDARCYS	PERMEABILITY FEET	POROSITY, PER CENT	POROSITY FEET	RESIDUAL SATURATIONS, PER CENT PORE SPACE		VISUAL EXAMINATION
	DEPTH	THICK					OIL	TOTAL WATER	
CORE NO. 2 (Cont'd)									
20	2687.4-88.2	0.8	0.4	0.32	21.1	16.88	2.8	74.4	FS SHY 25% SAND
21	2688.2-88.8	0.6	1.0	0.60	22.9	13.74	2.2	61.6	FS SHY 30% SAND
22	2688.8-89.6	0.8	0.5	0.40	22.3	17.84	1.8	73.5	FS SHY 50% SAND
23	2689.6-90.5	0.9	2.6	2.34	23.3	20.97	3.0	67.0	FS SHY 60% SAND
24	2690.5-91.3	0.8	0.5	0.40	19.7	15.76	3.0	82.7	FS SHY 40% SAND
25	2691.3-92.1	0.8	2.2	1.76	20.3	16.24	5.4	71.4	FS SHY 70% SAND
26	2692.1-93.0	0.9	0.2	0.18	29.0	26.10	2.8	52.1	FS SHY 50% SAND
27	2693.0-93.5	0.5	5.1	2.55	21.0	10.50	4.8	80.5	FS SHY 75% SAND
28	2693.5-94.3	0.8	0.6	0.48	19.1	15.28	9.4	70.2	FS SHY 25% SAND
29	2694.3-95.1	0.8	0.3	0.24	20.6	16.48	2.9	80.1	FS SHY 25% SAND
30	2695.1-95.9	0.8	1.6	1.28	22.8	18.24	4.8	76.3	FS SHY 25% SAND
31	2695.9-96.6	0.7	0.6	0.42	23.4	16.38	1.7	67.5	FS SHY 35% SAND
32	2696.6-97.4	0.8	2.6	2.08	19.4	15.52	2.1	81.4	FS SHY 40% SAND
33	2697.4-98.2	0.8	2.4	1.92	27.9	22.32	1.4	56.6	FS SHY 35% SAND
34	2698.2-99.0	0.8	-0.1	-0.1	22.0	17.60	3.6	78.6	FS SHY 30% SAND
35	2699.0-99.7	0.7	3.9	2.73	23.3	16.31	2.1	66.5	FS SHY 35% SAND
36	2699.7-00.5	0.8	4.4	3.52	24.7	19.76	Trace	64.4	FS SHY 40% SAND
37	2700.5-01.4	0.9	1.2	1.08	20.3	18.27	2.5	80.8	FS SHY 40% SAND
38	2701.4-02.2	0.8	5.1	4.08	18.9	15.12	Trace	58.7	FS SHY 25% SAND
39	2702.2-03.2	1.0	7.4	7.40	20.4	20.40	2.9	77.0	FS SHY 20% SAND
-	2703.2-03.6	0.4	-	-	-	-	-	-	SH
40	2703.6-04.4	0.8	-0.1	-0.1	21.2	16.96	2.4	80.7	FS SHY 15% SAND
41	2704.4-05.4	1.0	0.2	0.20	21.4	21.40	2.3	82.2	FS SHY 20% SAND
42	2705.4-06.2	0.8	1.6	1.28	20.6	16.48	3.9	79.6	FS SHY 15% SAND
43	2706.2-07.2	1.0	0.6	0.60	16.9	16.90	7.1	81.7	FS SHY 15% SAND
44	2707.2-08.1	0.9	0.4	0.36	19.2	17.28	4.7	83.3	FS SHY 10% SAND
45	2708.1-09.1	1.0	0.3	0.30	19.4	19.40	6.2	87.1	FS SHY 10% SAND
46	2709.1-10.0	0.9	0.1	0.09	19.9	17.91	3.5	84.9	FS SHY 10% SAND
47	2710.0-10.6	0.6	-0.1	-0.1	17.6	10.56	5.1	78.4	FS SHY 5% SAND
48	2710.6-10.9	0.3	-0.1	-0.1	17.9	5.37	3.4	78.8	FS SHY 60% SAND
49	2710.9-11.9	1.0	1.3	1.30	17.6	17.60	4.5	78.4	FS SHY 20% SAND
50	2711.9-12.6	0.7	0.6	0.42	23.0	16.10	2.6	81.3	FS SHY 20% SAND
51	2712.6-13.0	0.4	3.9	1.56	26.1	10.44	Trace	59.4	FS SHY 40% SAND
52	2713.0-13.8	0.8	0.5	0.40	15.0	12.00	4.0	76.7	FS SHY 20% SAND

APPENDIX II - cont'd.

WELL: UBR ARCAN GOVENLOCK 10-19-3-29 - cont'd

SAMPLE NUMBER	INTERVAL REPRESENTED, FEET		HORIZ. PERM TO AIR, MILLIDARCYS	PERMEABILITY FEET	POROSITY, PER CENT	POROSITY FEET	RESIDUAL SATURATIONS, PER CENT PORE SPACE		VISUAL EXAMINATION
	DEPTH	THICK					OIL	TOTAL WATER	
	CORE NO. 2 (Cont'd)								
53	2713.8-14.6	0.8	0.6	0.48	17.5	14.00	3.4	87.4	FS SHY 65% SAND
54	2714.6-15.5	0.9	1.2	1.08	20.9	18.81	3.3	74.6	FS SHY 35% SAND
55	2715.5-16.5	1.0	2.5	2.50	20.8	20.80	4.3	73.6	FS SHY 25% SAND
56	2716.5-17.5	1.0	-0.1	-0.1	19.0	19.00	6.3	84.2	FS SHY 20% SAND
57	2717.5-18.5	1.0	0.7	0.70	16.9	16.90	11.2	81.1	FS SHY 25% SAND
58	2718.5-19.5	1.0	0.6	0.60	16.8	16.80	6.0	86.3	FS SHY 25% SAND
59	2719.5-20.3	0.8	-0.1	-0.1	19.1	15.28	6.8	80.6	FS SHY 15% SAND
60	2720.3-21.1	0.8	1.2	0.96	18.2	14.56	3.3	64.3	FS SHY 40% SAND
61	2721.1-22.1	1 0	2.6	2.60	22.4	22.40	4.5	61.2	FS SHY 25% SAND
62	2722.1-23.1	1.0	-0.1	-0.1	20.2	20.20	10.4	83.2	FS SHY 10% SAND
63	2723.1-24.0	0.9	0.1	0.09	17.1	15.39	9.9	81.9	FS SHY 10% SAND
-	2724.0-25.0	1.0	-	-	-	-	-	-	SH
-	2725.0-32.0	7.0	-	-	-	-	-	-	LOST CORE.

APPENDIX II - cont'd.

WELL: AEG HORSHAM 11-8T-18-29
LOCATION: LSD 11-8T-18-29W3
FORMATION: MILK RIVER

SAMPLE NUMBER	INTERVAL REPRESENTED, FEET		PERM. MD. @ 900 PSIG	PERMEABILITY FEET	POROSITY, PER CENT	POROSITY FEET	RESIDUAL SATURATIONS, PER CENT PORE SPACE		ESTIMATED %			VISUAL EXAMINATIC
	DEPTH	THICK					OIL	TOTAL WATER	SAND	SILT	SHALE	
CORED INTERVAL	1480' - 1560'											
CORE NO. 1	1480' - 1500' (REC. 20.0') (5 BOXES)											
-	1480.0-81.1	1.1	-	-	-	-	-	-	5		95	
-	1481.1-81.5	0.4	-	-	-	-	-	-	0		100	
-	1481.5-90.3	8.8	-	-	-	-	-	-	0		100	
-	1490.3-90.6	0.3	-	-	-	-	-	-	-	-	-	SILTSTONE
A	1490.6-91.1	0.5	-0.01	-	13.7	6.85	0.0	73.0	5		95	
B	1491.1-92.6	1.5	-0.01	-	14.8	22.20	0.0	80.5	10		90	
C	1492.6-93.2	0.6	NP	-	15.2	9.12	0.0	83.6	10	50	40	
1	1493.2-93.7	0.5	4.04	2.02	17.0	8.50	0.0	77.7	20		80	
-	1493.7-94.6	0.9	-	-	-	-	-	-	10		90	
-	1494.6-94.9	0.3	-	-	-	-	-	-	-	-	-	SILTSTONE
2	1494.9-95.2	0.3	0.89	0.27	14.4	4.32	0.0	70.8	30		70	
-	1495.2-95.3	0.1	-	-	-	-	-	-	0		100	
3	1495.3-95.6	0.3	NP	-	15.9	4.77	0.0	87.4	20		80	
-	1495.6-96.3	0.7	-	-	-	-	-	-	5		95	
4	1496.3-96.4	0.1	58.00	5.80	26.2	2.62	0.0	58.1	90		10	
5	1496.4-96.6	0.2	0.84	0.17	16.2	3.24	0.0	81.5	30		70	
6	1496.6-97.4	0.8	0.29	0.23	14.7	11.76	0.0	83.0	20		80	
7	1497.4-98.0	0.6	-0.01	-	13.4	8.04	0.0	78.4	30		70	
8	1498.0-98.4	0.4	4.92	1.97	19.4	7.76	0.0	73.7	40		60	
-	1498.4-98.8	0.4	-	-	-	-	-	-	5		95	
-	1498.8-98.9	0.1	-	-	-	-	-	-	80		20	
-	1498.9-99.1	0.2	-	-	-	-	-	-	0		100	
9	1499.1-00.0	0.9	5.26	4.73	17.1	15.39	0.0	77.2	30		70	

SAMPLE NUMBER	INTERVAL REPRESENTED, FEET		PERM. MD.	PERMEABILITY FEET	POROSITY, PER CENT	POROSITY FEET	RESIDUAL SATURATIONS, PER CENT PORE SPACE		ESTIMATED %			VISUAL EXAMINATI(
	DEPTH	THICK	@ 900 PSIG				OIL	TOTAL WATER	SAND	SILT	SHALE	
CORE NO. 2	1500' - 1520' (REC. 20.0') (5 BOXES)											
10	1500.0-01.3	1.3	-0.01	-	15.0	19.50	0.0	48.7	10	90	0	
11	1501.3-02.2	0.9	-0.01	-	12.1	10.89	0.0	68.6	10	90	0	
12	1502.2-03.2	1.0	0.33	0.33	17.8	17.80	0.0	86.5	10	90	0	
13	1503.2-04.2	1.0	0.36	0.36	12.5	12.50	0.0	73.6	20	80	0	
14	1504.2-05.2	1.0	-0.01	-	12.7	12.70	0.0	7[illegible].2	20	80	0	
15	1505.2-06.2	1.0	-0.01	-	14.0	14.00	0.0	72.1	40	60	0	
16	1506.2-06.9	0.7	0.15	0.11	13.0	9.10	0.0	78.5	30	70	0	
17	1506.9-07.7	0.8	0.20	0.16	17.0	13.60	0.0	86.5	50	50	0	
18	1507.7-08.7	1.0	NP	-	17.2	17.20	0.0	85.5	10	90	0	
19	1508.7-09.5	0.8	0.08	0.06	12.9	10.32	0.0	79.1	30	70	0	
20	1509.5-10.4	0.9	-0.01	-	11.3	10.17	0.0	79.7	10	90	0	
21	1510.4-10.8	0.4	0.07	0.03	15.8	6.32	0.0	83.5	20	80	0	
-	1510.8-11.0	0.2	-	-	-	-	-	-	-	-	-	SILTSTONE
22	1511.0-12.0	1.0	0.13	0.13	16.6	16.60	0.0	78.9	20	80	0	
23	1512.0-12.5	0.5	-0.01	-	15.1	7.55	0.0	80.8	50	50	0	
24	1512.5-13.2	0.7	0.17	0.12	14.3	10.01	0.0	81.1	30	70	0	
25	1513.2-14.0	0.8	-0.01	-	12.0	9.60	0.0	80.0	30	70	0	
26	1514.0-14.8	0.8	-0.01	-	10.7	8.56	0.0	75.7	30	70	0	
27	1514.8-15.4	0.6	-0.01	-	10.2	6.12	0.0	65.7	10	90	0	
28	1515.4-15.8	0.4	-0.01	-	11.7	4.68	0.0	73.5	20	80	0	
29	1515.8-16.8	1.0	-0.01	-	12.0	12.00	0.0	81.7	20	80	0	
30	1516.8-17.3	0.5	0.08	0.04	14.0	7.00	0.0	85.0	40	60	0	
31	1517.3-18.3	1.0	0.08	0.08	12.9	12.90	0.0	86.1	20	80	0	
32	1518.3-18.7	0.4	0.07	0.03	14.8	5.92	0.0	83.8	10	90	0	
33	1518.7-19.2	0.5	-0.01	-	14.5	7.25	0.0	75.9	30	70	0	
34	1519.2-20.0	0.8	0.07	0.06	12.8	10.24	0.0	81.3	20	80	0	
CORE NO. 3	1520' - 1540' (REC. 20.0') (6 BOXES)											
-	1520.0-20.8	0.8	-	-	-	-	-	-	-	-	-	
35	1520.8-21.8	1.0	-0.01	-	12.1	12.10	0.0	86.0	5		95	
36	1521.8-22.8	1.0	0.08	0.08	12.9	12.90	0.0	81.4	5		95	
37	1522.8-23.8	1.0	0.08	0.08	11.2	11.20	0.0	80.4	5		95	
38	1523.8-24.8	1.0	0.15	0.15	13.8	13.80	0.0	85.5	5		95	
39	1524.8-25.8	1.0	0.24	0.24	14.7	14.70	0.0	83.0	5		95	

SAMPLE NUMBER	INTERVAL REPRESENTED, FEET		PERM. MD.	PERMEABILITY FEET	POROSITY, PER CENT	POROSITY FEET	RESIDUAL SATURATIONS, PER CENT PORE SPACE		ESTIMATED %			VISUAL EXAMINATIO
	DEPTH	THICK	@ 900 PSIG				OIL	TOTAL WATER	SAND	SILT	SHALE	
	CORE NO. 3 (Cont'd)											
40	1525.8-26.8	1.0	0.08	0.08	11.7	11.70	0.0	82.1	5		95	
41	1526.8-27.8	1.0	0.08	0.08	14.4	14.40	0.0	87.5	5		95	
42	1527.8-28.8	1.0	-0.01	-	13.0	13.00	0.0	87.7	5		95	
43	1528.8-29.8	1.0	-0.01	-	14.3	14.30	0.0	86.7	5		95	
44	1529.8-30.9	1.1	0.08	0.88	11.3	12.43	0.0	86.7	5		95	
-	1530.9-31.2	0.3	-	-	-	-	-	-	-	-	-	
45	1531.2-32.2	1.0	-0.01	-	11.3	11.30	0.0	80.5	20	40	40	SILTSTONE
46	1532.2-33.2	1.0	-0.01	-	13.8	13.80	0.0	85.5	10	45	45	
47	1533.2-33.9	0.7	0.24	0.17	14.6	10.22	0.0	89.0	20	40	40	
48	1533.9-34.9	1.0	0.08	0.08	15.4	15.40	0.0	86.4	10	45	45	
49	1534.9-35.9	1.0	0.08	0.08	12.8	12.80	0.0	85.2	30	35	35	
50	1535.9-36.8	0.9	0.08	0.07	13.8	12.42	0.0	73.2	10	45	45	
51	1536.8-37.1	0.3	NP	-	17.7	5.31	0.0	85.3	40	30	30	
52	1537.1-38.0	0.9	-0.01	-	13.7	12.33	0.0	83.9	30	35	35	
-	1538.0-40.0	2.0	-	-	-	-	-	-	5	90	5	
	CORE NO. 4	1540' - 1560' (REC. 20.0') (4 BOXES)										
-	1540.0-42.0	2.0	-	-	-	-	-	-			100	
53	1542.0-42.8	0.8	0.38	0.30	14.3	11.44	0.0	86.0	5	25	70	
54	1542.8-43.6	0.8	-0.01	-	14.5	11.60	0.0	82.1	5	20	75	
-	1543.6-44.0	0.4	-	-	-	-	-	-	-	-	-	
55	1544.0-45.0	1.0	-0.01	-	14.6	14.60	0.0	76.7	10	20	70	SILTSTONE
56	1545.0-46.0	1.0	-0.01	-	14.8	14.80	0.0	85.8	10	20	70	
57	1546.0-47.0	1.0	-0.01	-	14.1	14.10	0.0	84.4	10	20	70	
58	1547.0-48.0	1.0	NP	-	13.5	13.50	0.0	78.5	10	20	70	
59	1548.0-49.0	1.0	-0.01	-	11.3	11.30	0.0	71.7	10	20	70	
60	1549.0-50.0	1.0	-0.01	-	11.9	11.90	0.0	62.2	10	20	70	
61	1550.0-51.1	1.1	-0.01	-	12.0	13.20	0.0	78.3	5	25	70	
62	1551.1-52.2	1.1	-0.01	-	13.6	14.96	0.0	81.6	5	25	70	
63	1552.2-53.3	1.1	-0.01	-	13.4	14.74	0.0	76.1	5	25	70	
-	1553.3-53.5	0.2	-	-	-	-	-	-	-	-	-	
64	1553.5-54.5	1.0	-0.01	-	10.7	10.70	0.0	76.6	5	25	70	IRONSTONE
65	1554.5-55.5	1.0	-0.01	-	12.9	12.90	0.0	82.2	5	25	70	

WELL: AEG HORSHAM 11-8T-18-29

APPENDIX II - cont'd.

SAMPLE NUMBER	INTERVAL REPRESENTED, FEET		PERM. MD.	PERMEABILITY FEET	POROSITY, PER CENT	POROSITY FEET	RESIDUAL SATURATIONS, PER CENT PORE SPACE		ESTIMATED %			VISUAL EXAMINATION
	DEPTH	THICK	@ 900 PSIG				OIL	TOTAL WATER	SAND	SILT	SHALE	
	CORE NO. 4 (Cont'd)											
66	1555.5-56.5	1.0	-0.01	-	12.7	12.70	0.0	85.8	5	25	70	
67	1556.5-57.4	0.9	-0.01	-	12.8	11.52	0.0	80.5	20		80	
68	1557.4-58.7	1.3	-0.01	-	12.7	16.51	0.0	77.2	20		80	
-	1558.7-58.9	0.2	-	-	-	-	-	-	-	-	-	IRONSTONE
69	1558.9-60.0	1.1	-0.01	-	15.7	17.27	0.0	8,15	5		95	

NP - NO PERMEABILITY DUE TO FRACTURED NATURE OF CORE.

APPENDIX III

SARABAND Analyses from Upper Colorado strata in southwestern Saskatchewan.

APPENDIX III - cont'd.

WELL: SPC VIDORA 10-21-4-26
LOCATION: 10-21-4-26W4
FORMATION: MILK RIVER
DEPTH INTERVAL: 1869 - 2187 feet

Depth (ft.)	Perm. (MD)	Porosity %	Water Sat. %	Cum. Porosity (ft.)	Cum. Hycarb (ft.)
1869	0.4	12.0	100.0	28.03	2.16
1879	2.0	15.3	70.0	27.52	2.16
1897	2.0	15.4	100.0	25.82	2.12
1902	4.0	16.4	71.0	25.23	2.12
1906	3.0	15.9	69.0	24.70	2.67
1909	2.0	15.0	75.0	24.30	2.02
1910	5.0	16.9	73.0	24.14	1.98
1920	1.0	14.0	92.0	23.48	1.95
1934	6.0	16.0	65.0	22.46	1.94
1935	10.0	17.5	62.0	22.30	1.88
1936	10.0	18.4	61.0	22.12	1.81
1937	7.0	16.4	64.0	21.94	1.74
1945	1.0	13.5	100.0	21.28	1.69
1946	2.0	15.2	91.0	21.14	1.69
1947	5.0	17.1	77.0	20.98	1.66
1948	3.0	15.5	75.0	20.81	1.62
1949	0.7	12.7	100.0	20.66	1.60
1950	1.0	13.9	99.0	20.53	1.60
1951	1.0	13.8	99.0	20.39	1.60
1963	5.0	16.9	78.0	19.71	1.60
1964	4.0	16.4	74.0	19.55	1.56
1965	3.0	16.1	71.0	19.38	1.51
1966	2.0	14.7	94.0	19.23	1.49
1967	2.0	14.4	97.0	19.10	1.48
1969	0.2	10.7	100.0	18.88	1.48
1970	4.0	16.1	77.0	18.76	1.48
1971	3.0	15.9	71.0	18.59	1.44
1974	3.0	15.9	83.0	18.25	1.41
1976	1.0	13.6	100.0	18.01	1.40
2093	10.0	19.1	93.0	11.13	1.40
2094	10.0	19.1	97.0	10.94	1.39
2103	8.0	15.9	67.0	10.26	1.39
2113	1.0	13.8	96.0	9.30	1.33
2114	5.0	17.0	67.0	9.14	1.30
2116	1.0	13.6	93.0	8.85	1.25
2117	7.0	16.6	66.0	8.71	1.22

APPENDIX III - cont'd.

WELL: SPC VIDORA 10-21-4-26 - cont'd.

Depth (ft.)	Perm. (MD)	Porosity %	Water Sat. %	Cum. Porosity (ft.)	Cum. Hycarb (ft.)
2118	10.0	19.4	68.0	8.54	1.16
2119	20.0	20.2	71.0	8.35	1.10
2120	4.0	16.4	72.0	8.15	1.04
2121	2.0	15.2	74.0	8.00	1.02
2122	1.0	13.8	99.0	7.85	0.99
2123	2.0	15.0	75.0	7.72	0.98
2124	5.0	16.9	67.0	7.56	0.94
2125	4.0	16.6	67.0	7.39	0.88
2126	2.0	14.8	71.0	7.23	0.83
2127	2.0	14.7	76.0	7.08	0.80
2128	0.6	12.4	100.0	6.93	0.76
2139	3.0	15.3	69.0	6.17	0.76
2140	5.0	17.0	69.0	6.01	0.71
2141	5.0	17.0	69.0	5.84	0.66
2142	1.0	13.5	96.0	5.67	0.61
2143	2.0	14.5	77.0	5.53	0.60
2144	2.0	14.4	74.00	5.39	0.56
2145	0.6	12.4	99.0	5.26	0.54
2146	8.0	17.9	69.0	5.11	0.51
2147	3.0	16.0	68.0	4.94	0.46
2148	3.0	15.6	70.0	4.78	0.41
2149	6.0	17.3	71.0	4.62	0.36
2150	4.0	16.2	69.0	4.44	0.31
2151	3.0	15.8	69.0	4.28	0.26
2152	4.0	16.5	69.0	4.13	0.21
2153	5.0	17.1	70.0	3.97	0.16
2154	7.0	16.5	67.0	3.80	0.11
2155	2.0	14.3	76.0	3.63	0.05
2159	0.2	10.4	100.0	3.20	0.03
2187	1.0	13.6	87.0	1.83	0.03

APPENDIX III

WELL: SPC SENATE 7-34-3-28
LOCATION: 7-34-3-28W3
FORMATION: UPPER COLORADO SUBGROUP
DEPTH INTERVAL: 2776 - 2860 feet

Depth (ft.)	Perm. (MD)	Porosity %	Water Sat. %	Cum. Porosity (ft.)	Cum. Hycarb (ft.)
2776	0.7	12.8	100.0	4.00	0.89
2783	30.0	21.3	100.0	3.83	0.89
2784	80.0	24.3	100.0	3.61	0.89
2785	20.0	20.4	100.0	3.38	0.89
2786	10.0	19.1	100.0	3.19	0.89
2787	10.0	19.0	72.0	2.99	0.88
2788	20.0	18.7	50.0	2.79	0.81
2789	30.0	19.8	52.0	2.61	0.71
2790	0.3	11.4	95.0	2.41	0.62
2791	6.0	14.6	55.0	2.31	0.62
2795	10.0	18.3	60.0	2.04	0.59
2796	5.0	15.2	65.0	1.86	0.51
2798	7.0	16.2	62.0	1.65	0.48
2799	8.0	16.4	62.0	1.49	0.42
2800	8.0	16.7	61.0	1.35	0.36
2801	7.0	15.9	61.0	1.15	0.29
2802	8.0	16.1	58.0	1.00	0.23
2803	4.0	13.8	59.0	0.84	0.16
2804	20.0	18.0	54.0	0.71	0.13
2805	10.0	17.5	54.0	0.53	0.05
2806	0.1	9.8	100.0	0.38	0.00
2860	0.2	10.4	100.0	0.05	0.00

APPENDIX III- cont'd.

WELL: SPC GOVENLOCK 10-3-3-29
LOCATION: CTR 10-3-29W3
FORMATION: UPPER COLORADO SUBGROUP
DEPTH INTERVAL: 583-778 meter

Depth (m)	Porosity %	Water Sat. %
583-588	20.0	95.0
588-593	18.0	100.0
593-598	14.5	88.0
598-600	22.0	100.0
600-605	18.0	100.0
605-610	8.0	100.0
610-615	13.0	76.0
615-620	5.0	100.0
620-625	4.0	100.0
625-630	6.0	90.0
630-635	5.0	100.0
635-640	4.0	100.0
640-645	8.0	90.0
645-650	19.0	43.0
650-655	21.0	38.0
655-660	22.0	39.0
660-665	23.0	40.0
665-670	7.0	100.0
670-675	12.0	65.0
675-680	2.0	95.0
680-695	13.0	42.0
695-700	15.0	60.0
700-705	20.0	65.0
705-715	8.0	85.0
715-730	5.0	100.0
730-740	24.0	55.0
740-758	20.0	50.0
758-778	10.0	98.0

APPENDIX III - cont'd.

WELL: SPC-NHP-ARCO CLEARSITE 7-21-9-29
LOCATION: 7-21-9-29W3
FORMATION: UPPER COLARADO SUBGROUP
DEPTH INTERVAL: 2234 - 2998 feet

Depth (ft.)	Perm. (MD)	Porosity %	Water Sat. %
2234-2240	0.1	5.0	100.0
2240-2313	0.1	4.0	100.0
2313-2320	8.0	16.0	95.0
2320-2328	12.0	19.0	80.0
2328-2330	4.0	16.0	95.0
2330-2338	10.0	18.0	65.0
2338-2340	0.1	10.0	100.0
2340-2342	8.0	16.0	60.0
2342-2345	0.4	12.0	84.0
2345-2347	70.0	26.0	48.0
2347-2348	0.2	10.0	98.0
2348-2350	90.0	25.0	68.0
2350-2354	20.0	18.0	70.0
2354-2368	60.0	24.0	60.0
2368-2372	0.1	6.0	100.0
2372-2379	10.0	20.0	60.0
2379-2382	0.1	12.0	100.0
2382-2388	1.0	10.0	70.0
2388-2399	0.1	8.0	100.0
2399-2404	0.7	15.0	75.0
2404-2407	0.1	10.0	100.0
2407-2410	0.6	8.0	68.0
2410-2435	0.1	8.0	100.0
2435-2438	0.3	11.0	100.0
2438-2442	7.0	18.0	70.0
2442-2446	0.1	9.0	100.0
2446-2448	1.0	14.0	80.0
2448-2455	30.0	20.0	68.0
2455-2460	0.6	12.0	100.0
2460-2466	70.0	24.0	75.0
2466-2471	15.0	20.0	68.0
2471-2475	4.0	15.0	80.0
2475-2477	10.0	18.0	68.0
2477-2480	0.1	10.0	100.0
2480-2484	0.8	14.0	74.0
2484-2486	0.1	6.0	100.0
2486-2492	5.0	16.0	70.0

APPENDIX III - cont'd.

WELL: SPC-NHP-ARCO CLEARSITE 7-21-9-29 - cont'd.

Depth (ft.)	Perm. (MD)	Porosity %	Water Sat. %
2492-2508	0.1	5.0	100.0
2508-2517	0.3	12.0	98.0
2517-2524	30.0	20.0	65.0
2524-2526	0.2	9.0	100.0
2526-2531	30.0	20.0	65.0
2531-2535	0.5	10.0	100.0
2535-2540	0.1	8.0	100.0
2540-2542	0.6	11.0	98.0
2542-2547	0.1	8.0	100.0
2547-2550	2.0	14.0	70.0
2550-2552	0.1	5.0	100.0
2552-2557	4.0	17.0	82.0
2557-2560	50.0	21.0	78.0
2560-2566	0.1	8.0	100.0
2566-2568	1.5	14.0	80.0
2568-2575	0.3	12.0	90.0
2575-2582	0.1	10.0	100.0
2582-2593	4.0	15.0	75.0
2593-2600	0.1	5.0	100.0
2600-2604	1.0	12.0	80.0
2604-2608	25.0	20.0	72.0
2608-2614	0.1	8.0	100.0
2614-2618	0.1	3.0	100.0
2618-2626	0.1	7.0	100.0
2626-2636	0.1	1.0	100.0
2636-2644	0.1	4.0	100.0
2644-2656	0.1	2.0	100.0
2656-2663	0.1	4.0	100.0
2663-2670	0.1	1.0	100.0
2670-2683	0.1	8.0	100.0
2683-2704	0.1	1.5	100.0
2704-2714	0.1	3.0	100.0
2714-2716	0.6	12.0	100.0
2716-2724	0.1	4.0	100.0
2724-2730	0.1	1.0	100.0
2730-2756	0.1	6.0	100.0
2756-2758	0.5	12.0	80.0
2758-2768	0.1	7.0	100.0
2768-2785	0.1	4.0	100.0
2785-2788	0.7	12.0	84.0
2788-2802	0.1	10.0	100.0

WELL: SPC-NHP-ARCO CLEARSITE 7-21-9-29 - cont'd.

Depth (ft.)	Perm. (MD)	Porosity %	Water Sat. %
2802-2810	0.1	2.0	100.0
2810-2836	0.1	1.0	100.0
2836-2852	0.1	12.0	100.0
2852-2856	3.0	16.0	100.0
2856-2861	50.0	20.0	70.0
2861-2864	0.8	15.0	70.0
2864-2884	0.1	1.0	100.0
2884-2896	0.1	3.0	100.0
2896-2976	0.1	1.0	100.0
2976-2998	0.1	4.0	100.0

APPENDIX IV

Well-Log Analyses of Upper Colorado strata in southwestern Saskatchewan.

APPENDIX IV - cont'd.

WELL: CDN RES HB ARENA 7-35-1-26
LOCATION: CTR 7-35-1-26W3
FORMATION: UPPER COLORADO SUB GROUP
DEPTH INTERVAL: 2182-2917 feet

Depth (ft.)	Bulk Density (gm/cc)	Porosity %	Water Sat. %
2182-2208	2.37	18.5	100.0
2208-2220	2.43	14.0	97.0
2220-2228	2.42	15.0	97.0
2228-2238	2.44	13.5	80.0
2238-2248	2.45	13.0	95.0
2248-2276	2.42	15.0	92.0
2276-2280	2.44	13.5	92.0
2280-2290	2.46	12.5	90.0
2290-2295	2.45	13.0	95.0
2295-2306	2.38	18.0	97.0
2306-2321	2.47	12.0	56.0
2321-2330	2.48	11.0	75.0
2330-2350	2.49	10.5	80.0
2350-2355	2.47	12.0	70.0
2355-2375	2.48	11.0	100.0
2375-2385	2.41	15.5	100.0
2385-2394	2.47	12.0	70.0
2394-2415	2.46	12.5	70.0
2415-2452	2.43	14.0	68.0
2452-2460	2.48	11.0	75.0
2460-2468	2.47	12.0	95.0
2468-2490	2.43	14.0	80.0
2490-2500	2.45	13.0	95.0
2500-2510	2.43	14.0	90.0
2510-2520	2.45	13.0	95.0
2520-2529	2.48	11.0	82.0
2529-2534	2.44	13.5	100.0
2534-2546	2.38	18.0	95.0
2546-2554	2.52	8.5	100.0
2554-2564	2.41	15.5	100.0
2564-2570	2.45	13.0	100.0
2570-2575	2.46	12.5	97.0
2575-2590	2.43	14.0	95.0
2590-2593	2.49	10.5	95.0
2593-2600	2.47	12.0	85.0
2600-2650	2.46	12.5	90.0
2650-2670	2.42	15.0	95.0
2670-2682	2.39	17.0	100.0

APPENDIX IV - cont'd.

WELL: CDN RES HB ARENA 7-35-1-26 - cont'd.

Depth (ft.)	Bulk Density (gm/cc)	Porosity %	Water Sat. %
2682-2700	2.41	15.5	100.0
2700-2711	2.45	13.0	100.0
2711-2720	2.46	12.5	100.0
2720-2732	2.43	14.0	50.0
2732-2739	2.48	11.0	50.0
2739-2750	2.47	12.0	75.0
2750-2754	2.50	9.5	62.0
2754-2770	2.49	10.5	88.0
2770-2790	2.48	11.0	80.0
2790-2800	2.46	12.5	97.0
2800-2840	2.43	14.5	100.0
2840-2850	2.45	13.0	97.0
2850-2875	2.41	15.5	100.0
2875-2917	2.47	12.0	100.0

APPENDIX IV - cont'd.

WELL: SPC SHELL MAPLE CREEK 6-21-9-26
LOCATION: CTR 6-21-9-26W3
FORMATION: UBR COLORADO SUBGROUP
DEPTH INTERNAL: 2221-2880 feet

Depth (ft.)	Bulk Density (gm/cc)	Porosity %	Water Sat. %
2221-2225	2.32	21.5	74.0
2225-2232	2.29	23.5	70.0
2232-2241	2.32	21.5	74.0
2241-2251	2.30	23.0	74.0
2251-2264	2.26	25.0	70.0
2264-2270	2.35	19.5	82.0
2270-2288	2.32	21.5	53.0
2288-2291	2.37	18.5	70.0
2291-2320	2.27	24.5	76.0
2320-2330	2.28	24.0	74.0
2330-2335	2.33	20.5	76.0
2335-2345	2.23	27.0	80.0
2345-2354	2.26	25.0	82.0
2354-2376	2.36	19.0	80.0
2376-2389	2.39	18.0	74.0
2389-2393	2.30	23.0	76.0
2393-2400	2.35	19.5	74.0
2400-2413	2.32	21.5	76.0
2413-2422	2.36	19.0	82.0
2422-2428	2.35	19.5	100.0
2428-2436	2.36	19.0	74.0
2436-2445	2.33	20.5	74.0
2445-2457	2.37	18.5	82.0
2457-2474	2.32	21.5	74.0
2474-2510	2.31	22.0	80.0
2510-2536	2.34	20.0	85.0
2536-2541	2.26	25.0	95.0
2541-2550	2.25	26.0	100.0
2550-2556	2.27	24.5	100.0
2556-2570	2.26	25.0	100.0
2570-2612	2.32	21.5	80.0
2612-2615	2.45	13.0	82.0
2615-2622	2.43	19.0	70.0
2622-2630	2.35	19.5	74.0
2630-2645	2.39	17.0	72.0
2645-2700	2.33	20.5	72.0
2700-2720	2.31	22.0	76.0
2720-2735	2.30	23.0	82.0
2735-2744	2.23	27.0	100.0
2744-2755	2.26	25.0	100.0

APPENDIX IV - cont'd.

WELL: SPC SHELL MAPLE CREEK 6-21-9-26 - cont'd.

Depth (ft.)	Bulk Density (gm/cc)	Porosity %	Water Sat. %
2755-2763	2.30	23.0	100.0
2763-2786	2.26	25.0	100.0
2786-2810	2.35	19.5	85.0
2810-2817	2.37	20.0	74.0
2817-2847	2.30	23.0	95.0
2847-2855	2.32	21.5	100.0
2855-2863	2.37	20.0	100.0
2863-2868	2.48	11.0	75.0
2868-2875	2.40	16.5	82.0
2875-2880	2.38	18.0	95.0

APPENDIX IV - cont'd

WELL: SPC SHELL MAPLE CREEK 7-6-10-26
LOCATION: CTR 7-6-10-26W3
FORMATION: UPPER COLORADO SUBGROUP
DEPTH INTERVAL: 2008-2674 feet

Depth (ft.)	Bulk Density (gm/cc)	Porosity %	Water Sat. %
2008-2010	2.22	28.0	90.0
2010-2035	2.24	26.5	82.0
2035-2045	2.31	22.0	90.0
2045-2062	2.22	28.0	90.0
2062-2084	2.36	19.0	80.0
2084-2100	2.30	23.0	75.0
2100-2124	2.28	24.0	75.0
2124-2130	2.29	23.5	92.0
2130-2165	2.30	23.0	80.0
2165-2174	2.33	20.5	75.0
2174-2200	2.32	21.5	78.0
2200-2212	2.31	22.0	80.0
2212-2224	2.32	21.5	80.0
2224-2233	2.40	16.0	80.0
2233-2242	2.30	23.0	80.0
2242-2250	2.32	21.5	88.0
2250-2260	2.31	22.0	82.0
2260-2270	2.36	19.0	85.0
2270-2276	2.40	16.0	100.0
2276-2290	2.36	19.0	80.0
2290-2302	2.32	21.5	80.0
2302-2312	2.31	22.0	87.0
2312-2324	2.37	18.5	90.0
2324-2335	2.31	22.0	100.0
2335-2343	2.34	20.0	95.0
2343-2350	2.29	23.5	95.0
2350-2356	2.32	21.5	100.0
2356-2362	2.33	20.5	100.0
2362-2372	2.34	20.0	85.0
2372-2388	2.39	17.0	100.0
2388-2394	2.37	18.5	100.0
2394-2402	2.32	21.5	68.0
2402-2412	2.41	15.5	70.0
2412-2422	2.34	20.0	68.0
2422-2445	2.39	17.0	70.0
2445-2490	2.38	18.0	72.0
2490-2500	2.37	18.5	77.0
2500-2530	2.36	19.0	80.0
2530-2552	2.32	21.5	95.0
2552-2568	2.30	23.0	100.0

APPENDIX IV – cont'd.

WELL: SPC SHELL MAPLE CREEK 7-6-10-26 – cont'd.

Depth (ft.)	Bulk Density (gm/cc)	Porosity %	Water Sat. %
2568–2573	2.27	24.5	100.0
2573–2586	2.35	19.5	100.0
2586–2594	2.27	24.5	85.0
2594–2632	2.34	20.0	90.0
2632–2640	2.31	22.0	100.0
2640–2655	2.37	18.5	90.0
2655–2674	2.47	12.0	78.0

APPENDIX IV - cont'd.

WELL: SPC HUDSONS BAY SUPREME 7-10-2-27
LOCATION: CTR 7-10-2-27W3
FORMATION: UPPER COLORADO SUBGROUP
DEPTH INTERVAL: 2266-2900 feet

Depth (ft.)	Bulk Density (gm/cc)	Porosity %	Water Sat. %
2266-2278	2.30	23.0	58.0
2278-2282	2.37	18.5	55.0
2282-2292	2.24	26.5	58.0
2292-2300	2.37	18.5	53.0
2300-2305	2.34	20.0	58.0
2305-2315	2.32	21.5	60.0
2315-2330	2.25	26.0	70.0
2330-2350	2.22	28.5	56.0
2350-2355	2.37	18.5	52.0
2355-2380	2.40	16.5	60.0
2380-2390	2.39	17.0	57.0
2390-2396	2.43	14.5	54.0
2396-2422	2.48	11.0	65.0
2422-2438	2.27	24.5	55.0
2438-2450	2.35	19.5	60.0
2450-2453	2.46	12.5	59.0
2453-2464	2.32	21.5	82.0
2464-2480	2.25	26.0	60.0
2480-2523	2.37	18.5	56.0
2523-2530	2.35	19.5	60.0
2530-2544	2.39	17.0	70.0
2544-2554	2.45	13.0	80.0
2554-2567	2.42	15.0	82.0
2567-2580	2.40	16.5	85.0
2580-2592	2.47	12.0	100.0
2592-2604	2.39	17.0	100.0
2604-2630	2.40	16.5	100.0
2630-2644	2.41	15.5	100.0
2644-2662	2.46	12.5	100.0
2662-2674	2.48	11.0	95.0
2674-2685	2.37	18.5	97.0
2685-2698	2.44	13.5	99.0
2698-2735	2.40	16.5	95.0
2735-2748	2.36	19.0	100.0
2748-2764	2.38	18.0	100.0
2764-2775	2.43	14.5	100.0
2775-2785	2.34	20.0	100.0
2785-2795	2.42	15.0	100.0
2795-2800	2.54	7.0	100.0

APPENDIX IV - cont'd.

WELL: SPC HUDSONS BAY SUPREME 7-10-2-27 - cont'd.

Depth (ft.)	Bulk Density (gm/cc)	Porosity %	Water Sat. %
2800-2820	2.43	14.5	52.0
2820-2832	2.45	13.0	95.0
2832-2838	2.48	11.0	100.0
2838-2846	2.43	14.5	95.0
2846-2852	2.52	8.5	93.0
2852-2860	2.37	18.5	100.0
2860-2870	2.49	10.5	100.0
2870-2885	2.50	9.5	100.0
2885-2900	2.48	11.0	100.0

APPENDIX IV - cont'd.

WELL: POC MOBIL CYPRESS 7-12-6-27
LOCATION: CTR 7-12-6-27W3
FORMATION: UPPER COLORADO SUBGROUP
DEPTH INTERVAL: 2345-3090 feet

Depth (ft.)	Interval Transit Time (μsec/ft.)	Porosity %	Water Sat. %
2345-2355	120	33.0	95.0
2355-2390	114	30.0	80.0
2390-2410	120	33.0	90.0
2410-2432	110	28.5	85.0
2432-2440	112	29.0	87.0
2440-2470	116	31.5	80.0
2470-2480	106	26.0	85.0
2480-2510	112	29.0	82.0
2510-2520	85	15.5	90.0
2520-2536	116	31.5	87.0
2536-2543	110	28.5	100.0
2543-2560	107	26.5	70.0
2560-2580	108	27.0	75.0
2580-2595	119	32.5	68.0
2595-2606	117	32.0	82.0
2606-2622	119	32.5	87.0
2622-2640	116	31.5	100.0
2640-2720	117	32.0	78.0
2720-2750	120	33.0	90.0
2750-2770	112	29.0	60.0
2770-2780	102	24.5	55.0
2780-2830	116	31.5	58.0
2830-2870	119	32.5	87.0
2870-2890	120	33.0	90.0
2890-2900	106	26.0	55.0
2900-2920	102	24.5	100.0
2920-3000	110	28.5	78.0
3000-3040	120	33.0	85.0
3040-3054	116	31.5	100.0
3054-3068	114	30.0	100.0
3068-3073	82	14.0	75.0
3073-3090	95	21.0	90.0

APPENDIX IV - cont'd.

WELL: SPC NOEL SENATE 11-12-2-28
LOCATION: CTR 11-12-2-28W3
FORMATION: UPPER COLORADO SUBGROUP
DEPTH INTERVAL: 2100-2778 feet

Depth (ft.)	Bulk Density (gm/cc)	Porosity %
2100-2127	2.40	16.0
2127-2134	2.37	18.5
2134-2144	2.38	18.0
2144-2162	2.39	17.0
2162-2173	2.44	13.5
2173-2178	2.40	16.0
2178-2204	2.41	15.5
2204-2215	2.44	13.5
2215-2225	2.39	17.0
2225-2275	2.43	14.0
2275-2293	2.36	19.0
2293-2306	2.40	16.0
2306-2314	2.48	11.0
2314-2324	2.43	14.0
2324-2334	2.42	15.0
2334-2350	2.43	14.0
2350-2395	2.44	13.5
2395-2416	2.43	14.0
2416-2432	2.40	16.0
2432-2462	2.42	15.0
2462-2483	2.41	15.5
2483-2500	2.34	20.0
2500-2520	2.37	18.5
2520-2532	2.40	16.0
2532-2562	2.43	14.0
2562-2600	2.42	15.0
2600-2612	2.43	14.0
2612-2620	2.40	16.0
2620-2636	2.32	21.5
2636-2640	2.34	20.0
2640-2645	2.31	22.0
2645-2651	2.30	23.0
2651-2662	2.32	21.5
2662-2674	2.37	18.5
2674-2701	2.42	15.0
2701-2705	2.46	12.5
2705-2720	2.44	13.5
2720-2740	2.43	14.0
2740-2750	2.44	13.5
2750-2773	2.43	14.0
2773-2778	2.46	12.5

APPENDIX IV - cont'd.

WELL: SPC ET AL GOVENLOCK 10-6-4-28
LOCATION: CTR 10-6-4-28W3
FORMATION: UPPER COLORADO SUBGROUP
DEPTH INTERVAL: 2200-2850 feet

Depth (ft.)	Bulk Density (gm/cc)	Porosity %	Water Sat. %
2200-2212	2.32	21.5	90.0
2212-2220	2.40	16.0	92.0
2220-2248	2.39	17.0	85.0
2248-2256	2.40	16.0	95.0
2256-2274	2.38	18.0	95.0
2274-2286	2.39	17.0	97.0
2286-2294	2.38	18.0	95.0
2294-2305	2.37	18.5	98.0
2305-2336	2.40	16.0	100.0
2336-2350	2.36	19.0	92.0
2350-2358	2.37	18.5	90.0
2358-2363	2.40	16.0	92.0
2363-2372	2.41	15.5	100.0
2372-2382	2.43	14.0	100.0
2382-2390	2.37	18.5	100.0
2390-2410	2.39	17.0	90.0
2410-2480	2.37	18.5	95.0
2480-2545	2.35	19.5	75.0
2545-2552	2.34	20.0	90.0
2552-2558	2.40	16.0	98.0
2558-2570	2.34	20.0	95.0
2570-2590	2.40	16.0	95.0
2590-2606	2.38	18.0	95.0
2606-2620	2.35	19.5	75.0
2620-2636	2.40	16.0	90.0
2636-2650	2.38	18.0	88.0
2650-2670	2.37	18.5	80.0
2670-2675	2.35	19.5	100.0
2675-2690	2.34	20.0	100.0
2690-2702	2.33	20.5	100.0
2702-2726	2.30	23.0	100.0
2726-2735	2.38	18.0	85.0
2735-2745	2.39	17.0	100.0
2745-2753	2.40	16.0	70.0
2753-2760	2.46	12.5	90.0
2760-2770	2.42	15.0	75.0
2770-2780	2.40	16.0	70.0
2780-2788	2.39	17.0	95.0
2788-2795	2.43	14.0	90.0
2795-2810	2.39	17.0	100.0
2810-2824	2.43	14.0	100.0
2824-2850	2.38	18.0	100.0

APPENDIX IV - cont'd

WELL: SPC POC AMOCO SENATE 7-15-4-28
LOCATION: CTR 7-15-4-28W3
FORMATION: UPPER COLORADO SUBGROUP
DEPTH INTERVAL: 2218-2864 feet

Depth (ft.)	Bulk Density (gm/cc)	Porosity %	Water Sat. %
2218-2220	2.38	18.0	50.0
2220-2250	2.35	19.50	80.0
2250-2260	2.36	19.0	80.0
2260-2270	2.34	20.0	100.0
2270-2287	2.30	23.0	82.0
2287-2296	2.23	27.0	78.0
2296-3332	2.40	16.0	70.0
3332-2400	2.37	18.5	78.0
2400-2444	2.40	16.0	82.0
2444-2464	2.25	26.0	80.0
2464-2612	2.38	18.0	100.0
2612-2640	2.35	19.5	75.0
2640-2657	2.38	18.0	100.0
2657-2675	2.39	17.0	100.0
2675-2688	2.44	13.5	95.0
2688-2710	2.37	18.5	82.0
2710-2740	2.35	19.5	92.0
2740-2770	2.36	19.0	85.0
2770-2788	2.35	19.5	100.0
2788-2792	2.34	20.0	90.0
2792-2810	2.33	20.5	100.0
2810-2820	2.40	16.0	98.0
2820-2848	2.42	15.0	100.0
2848-2854	2.41	15.5	90.0
2854-2864	2.38	18.0	100.0

APPENDIX IV - cont'd

WELL: UBR AMOCO BATTLE CK 6-17-6-28
LOCATION: CTR 6-17-6-28W3
FORMATION: UPPER COLORADO SUBGROUP
DEPTH INTERVAL: 2680-3274 feet

Depth (ft.)	Interval Transit Time (μsec/ft.)	Porosity %
2680-2695	110	28.5
2695-2720	102	24.5
2720-2755	100	23.0
2755-2762	75	10.0
2762-2768	110	28.5
2768-2782	115	30.5
2782-2787	114	30.0
2787-2802	117	32.0
2802-2814	108	27.0
2814-2835	117	32.0
2835-2864	108	27.0
2864-2882	112	29.0
2882-2900	68	6.0
2900-2982	116	31.5
2982-3020	117	32.0
3020-3054	116	31.5
3054-3078	101	23.5
3078-3102	110	28.5
3102-3125	102	24.5
3125-3155	117	32.0
3155-3170	120	33.0
3170-3183	121	33.5
3183-3196	120	33.0
3196-3202	110	28.5
3202-3225	100	23.0
3225-3254	106	26.0
3254-3262	102	24.5
3262-3274	110	28.5

APPENDIX IV

WELL: SPC MERRYFLAT 7-19-6-28
LOCATION: 7-19-6-28W3
FORMATION: MILK RIVER
DEPTH INTERVAL: 2224 - 2632 feet

Depth (ft.)	Bulk Density (gm/cc)	Porosity %
2224-2236	2.45	13.0
2236-2250	2.40	16.5
2250-2256	2.37	18.5
2256-2272	2.40	16.5
2272-2280	2.38	18.0
2280-2400	2.40	16.5
2400-2447	2.42	15.0
2447-2460	2.39	17.0
2460-2484	2.45	13.0
2484-2496	2.37	18.5
2496-2506	2.44	13.5
2506-2530	2.40	16.5
2530-2540	2.42	15.0
2540-2570	2.45	13.0
2570-2580	2.37	18.5
2580-2590	2.35	19.5
2590-2600	2.37	18.5
2600-2610	2.39	17.0
2610-2627	2.37	18.5
2627-2632	2.45	13.0

APPENDIX IV - cont'd

WELL: SPC GOVENLOCK 10-3-3-29
LOCATION: CTR 10-3-3-29W3
FORMATION: UPPER COLORADO SUBGROUP
DEPTH INTERVAL: 583-778 Meter

Depth (m)	Bulk Density (Mg/m^3)	Porosity %
583-588	2.33	20.5
588-593	2.37	18.5
593-598	2.38	18.0
598-600	2.35	19.5
600-605	2.40	16.0
605-610	2.38	18.0
610-615	2.37	18.5
615-620	2.39	17.0
620-625	2.40	16.0
625-630	2.42	15.0
630-635	2.40	16.0
635-640	2.39	17.0
640-645	2.38	18.0
645-650	2.25	26.0
650-655	2.39	17.0
655-660	2.42	15.0
660-665	2.43	14.0
665-670	2.38	18.0
670-675	2.37	18.5
675-680	2.36	19.0
680-695	2.38	18.0
695-700	2.41	15.5
700-705	2.37	18.5
705-715	2.34	20.0
715-730	2.40	16.0
730-740	2.43	14.0
740-758	2.36	19.0
758-778	2.43	14.0

APPENDIX IV - cont'd.

WELL: SPC SIEBENS ET AL MERRYFLAT 7-25-6-29
LOCATION: 7-25-6-29W3
FORMATION: UPPER COLORADO SUBGROUP
DEPTH INTERVAL: 2625-3199 feet

Depth (ft.)	Bulk Density (gm/cc)	Porosity %
2625-2676	2.22	28.0
2676-2685	2.40	16.0
2685-2694	2.35	19.5
2694-2704	2.23	27.0
2704-2709	2.33	20.5
2709-2720	2.34	20.0
2720-2736	2.17	30.5
2736-2756	2.23	27.0
2756-2768	2.27	24.5
2768-2800	2.25	26.0
2800-2820	2.14	32.5
2820-2832	2.28	24.0
2832-2837	2.38	18.0
2837-2852	2.34	20.0
2852-2869	2.38	18.0
2869-2904	2.32	21.5
2904-2918	2.31	22.0
2918-2924	2.35	19.5
2924-2980	2.28	24.0
2980-3010	2.32	21.5
3010-3036	2.33	20.5
3036-3045	2.43	14.0
3045-3068	2.31	22.0
3068-3092	2.32	21.5
3092-3110	2.25	26.0
3110-3134	2.35	19.5
3134-3148	2.38	18.0
3148-3162	2.34	20.0
3162-3185	2.28	24.0
3185-3199	2,30	23.0

APPENDIX IV - cont'd.

WELL: SPC SIEBENS MERRYFLAT 9-21-6-30
LOCATION: CTR 9-21-6-30W3
FORMATION: UPPER COLORADO SUBGROUP
DEPTH INTERVAL: 2700-3458 feet

Depth (ft.)	Porosity %	Water Sat. %
2700-2721	22.25	90.0
2721-2744	15.00	75.0
2744-2765	18.30	60.0
2765-2780	16.50	80.0
2780-2796	18.00	92.0
2796-2814	29.60	93.0
2814-2820	18.60	80.0
2820-2834	30.00	92.0
2834-2870	27.40	95.0
2870-2897	27.20	80.0
2897-2918	30.00	98.0
2918-3085	26.00	95.0
3085-3098	19.00	95.0
3098-3112	19.50	100.0
3112-3117	30.00	100.0
3117-3149	17.00	100.0
3149-3170	22.00	93.0
3170-3179	20.00	100.0
3179-3200	30.0	95.0
3200-3215	29.0	90.0
3215-3254	23.0	100.0
3254-3275	20.0	100.0
3275-3322	18.0	100.0
3322-3342	29.0	90.0
3342-3345	28.5	100.0
3345-3358	28.0	87.0
3358-3375	26.5	100.0
3375-3402	24.0	100.0
3402-3416	26.5	100.0
3416-3438	27.6	100.0
3438-3458	15.6	95.0

APPENDIX V

Elevations of main correlation surfaces of the Upper Colorado succession in southwestern Saskatchewan.

APPENDIX V

FORMATION TOPS

WELL NAME	LOCATION	KB (m)	MARTIN SANDY ZONE	BOWDOIN SANDSTONE	PHILLIPS SANDSTONE	LOWER COLORADO
CENPET ET AL EASTEND 7-17-6-20	7-17-6-20W3	983.0	856	920	992	1033
PENZL ET AL W. 16-5-4-21	16-5-4-21W3	932.0	771	841	917	973
ALTAIR FRONTIER 9-17-4-21	9-17-4-21W3	969.0	811	881	954	1010
PACIFIC LOOMIS 14-28-4-21	14-28-4-21W3	961.3	823	895	967	1020
SOCONY WOODLY SOUTHERN N. EASTDROOM 15-4	15-4-5-21W3	953.0	811	876	946	997
PACIFIC WHITEMUD 6-22-5-21	6-22-5-21W3	937.0	808	873	942	991
SOCONY MOBIL EASTEND 10-36-5-21	10-36-5-21W3	944.0	811	879	951	997
DELHI-HUSKY-PHILLIPS RICHFIELD STONE No. 13-16	13-16-9-21W3	1072.0	851	927	1002	1021
HOPE MIDCAL-CLAYDON 7-5-2-22	7-5-2-22W3	962.0	808	876	960	1020
GPD CLAYDON 7A-16-2-22	7-16-2-22W3	954.6	802	869	948	1006
TIDEWATER RUSTY CROWN No. 5-11	5-11-3-22W3	905.0	750	820	898	956
CLAYDON No. 16-20	16-20-3-22W3	-	759	823	899	960
ALTAIR OLIPHANT LOOAIS 11-36-3-22	11-36-3-22W3	938.0	783	853	930	989
SUPIERTEST ET AL STAYNORY 14-2-1-23	14-2-1-23W3	966.0	805	872	963	1024
CANADA SOUTHERN SHELL BOUNDARY No. 16-36	16-36-1-23W3	987.0	838	902	986	1047

APPENDIX V - cont'd

WELL NAME	LOCATION	KB (m)	MARTIN SANDY ZONE	BOWDOIN SANDSTONE	PHILLIPS SANDSTONE	LOWER COLORADO
WILLIAMSON B.A. KATHERINE 8-29-3-23	8-29-3-23W3	941.0	768	833	913	973
B.A. EASTEND 12-7-4-23	12-7-4-23W3	973.0	789	858	934	997
SOCONY WESTERN PRAIRIE ROVENSCRAG No. 1	2-18-6-23W3	1002.0	814	878	963	1010
B.A. EASTEND SNIDER 2-28-7-23	2-28-7-23W3	1147.0	945	1021	1097	1140
UNGAS DIVIDE 11-11-2-24	11-11-2-24W3	962.5	785	863	940	1000
B.A. EASTEND ANDREW 16-21-~~4~~-24	16-21-4-24W3	956.0	750	817	895	957
BONANZA ET AL BATTLE CREEK 13-16-5-221	13-16-5-24W3	984.0	777	837	920	980
SOCONY WESTERN PRAIRIE PALISADE No. 1	4-11-6-24W3	1041.0	839	899	988	1035
G. CON ET AL MURRAYDALE 6-30-8-24	6-30-8-24W3	1218.0	975	1056	1134	1175
RICHFIELD JACK PAT LAKE No. 2	7-9-9-24W3	1204.0	975	1048	1120	1158
AMUROX ET AL RUBRIC 10-27-9-24	10-27-9-24W3	1176.0	949	1021	1099	1132
UNION MAPLE CREEK No. 13-16	13-16-10-24W3	962.0	738	811	885	920
UNGAS CAN-GEO ARENA 6-30-1-25	CTR 6-30-1-25W3	895.2	676	737	834	896
CANADA SOUTHERN SHELL ARENA No. 14-9	14-9-2-25W3	917.0	710	771	864	925
CO-OP CYPRESS No. 1	14-2-3-25W3	1078.0	867	928	1018	1077

APPENDIX V - cont'd

WELL NAME	LOCATION	KB (m)	MARTIN SANDY ZONE	BOWDOIN SANDSTONE	PHILLIPS SANDSTONE	LOWER COLORADO
SPC POC AMOCO VIDORA 10-9-4-25	10-9-4-25W3	963.0	739	802	888	-
UBR AMOCO ROBSART 6-29-4-25	SE 6-29-4-25W3	751.6	716	777	865	927
IMPERIAL ET AL ROBSART 1-1-5-25	1-1-5-25W3	962.0	744	806	890	947
G CON ET AL BELANGER 10-23-7-25	10-23-7-25W3	1127.0	891	963	1051	1097
G CON ET AL DAVIS 10-9-8-25	10-9-8-25W3	1137.0	884	957	1047	1094
IDE NEW GARDENS 1-23-8-25	1-23-8-25W3	1216.0	965	1036	1124	1169
CDN RES HB ARENA 7-35-1-26	CTR 7-35-1-26W3	891.2	665	725	826	889
CDN RES DECALTA BATTLE CR 12-27-3-26	SW 12-27-3-26W3	963.8	726	780	873	937
SPC VIDORA 10-21-4-26	10-21-4-26W3	947.0	705	765	856	902
SPC VIDORA 10-24-4-26	CTR 10-24-4-26W3	945.8	705	762	850	902
SPC VIDORA 7-25-4-26	CTR 7-25-4-26W3	952.5	710	771	861	908
UBR AMOCO CONSUL 6-29-4-26	SW 6-29-4-26W3	941.2	686	747	842	909
SPC AMOCO VIDORA 6-6-5-26	6-6-5-26W3	954.0	680	753	849	910
SPC ROBSART 7-16-5-26	CTR 7-16-5-26W3	965.6	698	769	862	908
SPC SHELL MAPLE CREEK 6-21-9-26	CTR 6-21-9-26W3	947.3	677	747	840	878
SPC SHELL MAPLE CREEK 7-6-10-26	CTR 7-6-10-26W3	884.8	612	683	778	815
SPC WOOD PILE 11-15-1-27	11-15-1-27W3	892.5	640	701	808	-

APPENDIX V - cont'd.

WELL NAME	LOCATION	(m)	MARTIN SANDY ZONE	BOWDOIN SANDSTONE	PHILLIPS SANDSTONE	LOWER COLORADO
SPC HUDSONS BAY SUPREME 7-10-2-27	7-10-2-27W3	940.3	691	750	855	914
HB ARENA 10-12-2-27	10-12-2-27W3	937.3	677	737	841	904
POC NOEL SUPREME 6-2-2-27	CTR 6-20-2-27W3	934.5	678	737	840	900
HB GOVENLOCK 10-6-3-27	10-6-3-27W3	934.5	662	719	823	882
SPC SENATE 10-18-4-27	10-18-4-27W3	962.9	677	741	843	878
SPC NOTUKEU 11-6-5-27	CTR 11-6-5-27W3	978.4	678	750	850	911
SPC WEST PLAINS 10-7-5-27	10-7-5-27W3	973.2	678	750	850	910
SPC WEST PLAINS 11-12-5-27	11-12-5-27W3	957.4	681	754	852	913
UBR AMOCO BATTLE CREEK 6-16-5-27	CTR 6-16-5-27W3	976.0	682	756	853	914
SPC CYPRESS LAKE 7-21-5-27	CTR 7-21-5-27W3	979.0	690	762	859	902
SPC AMOCO W. PLAINS 7-31-5-27	7-31-5-27W3	1002.0	712	786	888	-
SCURRY CYPRESS LAKE 7-4-6-27	7-4-6-27W3	959.0	689	762	861	919
SPC CYPRESS LAKE 10-10-6-27	10-10-6-27W3	1027.0	751	824	919	1010
POC MOBIL CYPRESS 7-12-6-27	CTR 7-12-6-27W3	986.3	715	791	885	942
BA COOP CABIAN CYPRESS LAKE 2-26	2-26-6-27W3	1090.0	820	895	991	1045
CANADA SOUTHERN WOODPILE No. 7-6	7-6-1-28W3	846.0	533	613	732	788
SHELL CABEREAN GOVENLOCK No. 1	2-7-1-28W3	843.0	539	620	736	792

APPENDIX V - cont'd

WELL NAME	LOCATION	KB (m)	MARTIN SANDY ZONE	BOWDOIN SANDSTONE	PHILLIPS SANDSTONE	LOWER COLORADO
SPC WILLOW CREEK 11-20-1-28	11-20-1-28W3	860.0	557	637	750	-
SPC NOEL ET AL SENATE 11-8-2-28	CTR 11-8-2-28W3	888.5	597	655	767	835
SPC NOEL SENATE 11-12-2-28	CTR 11-12-2-28W3	920.8	640	710	814	885
SPC SENATE 11-24-2-28	CTR 11-24-2-28W3	904.7	632	708	816	890
SPC AMOCO SENATE 7-4-3-28	7-4-3-28W3	930.0	625	798	796	-
UBR AMOCO SENATE 10-9-3-28	10-9-3-28W3	950.1	652	709	818	878
SPC SENATE 7-34-3-28	7-34-3-28W3	983.3	678	742	850	-
SPC SENATE 10-3-4-28	SW 10-3-4-28W3	972.3	664	734	838	881
SPC ET AL GOVENLOCK 10-6-4-28	CTR 10-6-4-28W3	973.8	654	724	832	893
SPC POC AMOCO SENATE 7-15-4-28	CTR 7-15-4-28W3	982.4	676	747	851	914
SPC SENATE 11-19-4-28	11-19-4-28W3	983.9	666	735	840	905
POC AMOCO SENATE 11-22-4-28	CTR 11-22-4-28W3	982.7	677	748	852	913
SPC AMOCO BATTLE CREEK 11-36-4-28W3	11-36-4-28W3	978.0	681	750	852	911
SPC ET AL W. PLAINS 7-10-5-28	CTR 7-10-5-28W3	993.7	686	759	862	931
SPC AMOCO W. PLAINS 10-33-5-28	10-33-5-28W3	1030.0	711	786	888	-
SPC MERRYFLAT 10-15-6-28	10-15-6-28W3	1069.9	769	838	940	1000
UBR AMOCO BATTLE CREEK 6-17-6-28	CTR 6-17-6-28W3	1119.2	804	878	977	1039

APPENDIX V - cont'd

WELL NAME	LOCATION	KB (m)	MARTIN SANDY ZONE	BOWDOIN SANDSTONE	PHILLIPS SANDSTONE	LOWER COLORADO
SPC MERRYFLAT 7-19-6-28	7-19-6-28W2	1117.1	797	871	972	1029
SPC GOVENLOCK 10-3-3-29	CTR 10-3-3-29W3	914.1	583	645	758	-
SPC ET AL SENATE 7-12-3-29	CTR 7-12-3-29W3	939.1	625	682	792	-
UBR ARCAN GOVENLOCK 10-19-3-29	CTR 10-19-3-29W3	970.5	633	696	809	866
CANADIAN EXPORT GAS GOV[illegible] No. [illegible]o. 628	6-28-3-29W3	940.9	619	678	790	845
UB[illegible] MIDDLE CREEK 10-20-4-29	SE 10-20-4-29W3	986.1	657	719	828	888
SPC SIEBENS MERRYFLAT 7-12-6-29	7-12-6-29W3	1078.4	760	834	938	-
SPC SIEBENS MERRYFLAT 7-20-6-29	CTR 7-20-6-29W3	1167.1	832	904	1008	-
CAN. DELHI ET AL BATTLE No. 1	16-21-6-29W3	1105.0	777	850	956	1012
SPC SIEBENS ET AL MERRYFLAT 7-25-6-29	7-25-6-29W3	1117.1	800	872	975	1033
SPC-NHP-ARCO CLEARSITE 7-21-9-29	7-21-9-29W3	1010.4	681	762	869	914
SPC SIEBENS BATTLE CREEK 7-13-5-30	7-13-5-30W3	1030.2	680	754	864	-
CAN. DELHI ET AL CYPRESS HILL No. 1	9-9-6-30W3	1119.0	759	832	945	1000
SPC SIEBENS MERRYFLAT 9-21-6-30	CTR 9-21-6-30W3	1172.0	810	887	1001	1054
SPC SIEBENS MERRYFLAT 7-26-6-30	7-26-6-30W3	1204.3	853	930	1036	-

APPENDIX VI

Water Analyses from the Upper Colorado strata of southwestern Saskatchewan.

APPENDIX VI

WATER ANALYSIS

WELL NAME	LOCATION	KB (m)	Depth Interval (m)	Formation Water Resistivity (ohm-m)	Concentration Total Solids (mg/L)	Stratigraphic Interval
GPD CLAYDON 7A-16-2-22	7-16-2-22W3	954.6	940-960	0.512	9714	Second White Specks
			843-861	0.525	9226	Medicine Hat Sandstone
UNGAS CAN GEO ARENA 6-30-1-25	CTR 6-30-1-25W3	895.2	834-837	0.491	11868	Second White Specks
			712-716	0.374	26050	Medicine Hat Sandstone
SPC VIDORA 10-21-4-26	10-21-4-26W3	947.0	708-710	0.410	-	Medicine Hat Sandstone
SPC VIDORA 10-24-4-26	CTR 10-24-4-26W3	945.8	835-902	1.030	5726	Second White Specks
SPC VIDORA 7-25-4-26	CTR 7-25-4-26W3	952.5	859-882	1.280	5290	Second White Specks
SPC ROBSART 7-16-5-26	CTR 7-16-5-26W3	965.6	867-875	0.730	7859	Second White Specks
			760-769	0.876	5920	Medicine Hat Sandstone
POC NOEL SUPREME 6-20-2-27	CTR 6-20-2-27W3	934.5	835-854	0.523	13652	Second White Specks
SPC NOTUKEU 11-6-5-27	CTR 11-6-5-27W3	978.4	852-914	2.500	2655	Second White Specks
UBR AMOCO BATTLE CREEK 6-16-5-27	CTR 6-16-5-27W3	976.0	854-869	0.349	19188	Second White Specks
POC MOBIL CYPRESS 7-12-6-27	CTR 7-12-6-27W3	986.3	876-901	1.660	3964	Second White Specks
HOMESTEAD SHELL GAP 11-20-8-27	CTR 11-20-8-27W3	1134.1	1015-1017	0.32-0.49	23413-14860	Second White Specks
SPC NOEL SENATE 11-12-2-28	CTR 11-12-2-28W3	920.8	794-807	0.465	14429	Second White Specks
SPC SENATE 11-24-2-28	CTR 11-24-2-28W3	904.7	810-825	0.630	9934	Second White Specks

APPENDIX VI - cont'd

WELL NAME	LOCATION	KB (m)	Depth Interval (m)	Formation Water Resistivity (ohm-m)	Concentration Total Solids (mg/L)	Stratigraphic Interval
UBR NOEL SENATE 11-28-2-28	CTR 11-28-2-28W3	929.7	804-820	0.208	36960	Second White Specks
SPC ET AL W. PLAINS 7-10-5-28	CTR 7-10-5-28W3	993.7	865-870	0.911	7494	Second White Specks
SPC MERRYFLAT 10-15-6-28	10-15-6-28W3	1069.9	938-951	0.618	9606	Second White Specks
SPC MERRYFLAT 7-19-6-28	7-19-6-28W3	1117.1	960-992	0.459	-	Second White Specks
SPC SIEBENS ET AL MERRYFLAT 7-25-6-29	7-25-6-29W3	1105.0	963-1000	0.700	9310	Second White Specks
SPC-NHP-ARCO CLEARSITE 7-21-9-29	7-21-9-29W3	1010.4	672-717	0.799	6604	Medicine Hat Sandstone

APPENDIX VII

Gas Analyses from the Upper Colorado strata of southwestern Saskatchewan.

APPENDIX VII

GAS ANALYSIS

WELL: UBR AMOCO ROBSART 6-29-4-25
LOCATION: LSD 6-29-4-25W3
FORMATION: SECOND WHITE SPECKS
DEPTH INTERVAL: 865.5 - 948 meter

Component	Mole %
H_2	0.00
He	0.00
N_2	4.71
CO_2	Trace
H_2S	0.00
C_1	94.87
C_2	0.30
C_3	0.08
IC_4	0.02
NC_4	0.02
IC_5	Trace
NC_5	Trace
C_6	0.00
C_7	0.00
C_8	0.00
C_9	0.00
C_{10}	0.00
TOTAL	100.00

Gross Heating Value MJ/M^3
(15°C and 101.325 kPa)

Calculated: 36.09

Specific Gravity
Calculated: 0.576

Pseudo Critical Properties
(Calculated)

PPC: 4596.37 kPa
PTC: 188.72 k

APPENDIX VII - cont'd

WELL: SPC VIDORA 7-25-4-26
LOCATION: 7-25-4-26W3
FORMATION: SECOND WHITE SPECKS
DEPTH INTERVAL: 859.5–882.4 Meter

Component	Mole %
H_2	0.00
He	0.23
N_2	8.16
CO_2	0.42
H_2S	0.00
C_1	90.80
C_2	~~0.27~~
C_3	0.09
IC_4	0.02
NC_4	0.01
IC_5	Trace
NC_5	Trace
C_6	Trace
C_7	Trace
C_8	Trace
C_9	0.00
C_{10}	0.00
TOTAL	100.00

Gross Heating Value MJ/M^3
(15°C and 101.325 kPa)

Calculated: 34.67

Specific Gravity

Calculated: 0.593
Measured: 0.598

Pseudo Critical Properties
(Calculated)

PPC: 4554.18 kPa
PTC: 18633 k

Mol. Wt. Total Gas: 17.19
C_7+: 0.00

APPENDIX VII - cont'd

WELL: SPC ROBSART 7-16-5-26
LOCATION: 7-16-5-26W3
FORMATION: SECOND WHITE SPECKS
DEPTH INTERVAL: 867 - 874.7 Meter

Component	Mole %
H_2	0.02
He	0.27
N_2	5.19
CO_2	0.00
H_2S	0.00
C_1	94.11
C_2	0.32
C_3	0.07
IC_4	0.01
NC_4	0.01
IC_5	Trace
NC_5	Trace
C_6	Trace
C_7	0.00
C_8	0.00
C_9	0.00
C_{10}	0.00
TOTAL	100.00

Gross Heating Value MJ/M^3
(15°C and 101.325 kPa)

Calculated: 35.8

Specific Gravity
Calculated: 0.577
Measured: 0.583

Pseudo Critical Properties
(Calculated)

PPC: 4577.7 kPa
PTC: 187.66 k

Mol. Wt. Total Gas: 16.70
C_7+: 0.00

APPENDIX VII-cont'd

WELL: SPC SHELL MAPLE CREEK 6-21-9-26
LOCATION: 6-21-9-26W3
FORMATION: MEDICINE HAT
DEPTH INTERVAL: 654.7 - 716.7 Meter

Component	Mole %
H_2	0.00
He	0.14
N_2	6.98
CO_2	0.09
H_2S	0.00
C_1	92.15
C_2	0.64
C_3	Trace
IC_4	0.00
NC_4	0.00
IC_5	0.00
NC_5	0.00
C_6	0.00
C_7	0.00
C_8	0.00
C_9	0.00
C_{10}	0.00
TOTAL	100.00

Gross Heating Value MJ/M^3
(15°C and 101.325 kPa)

Calculated: 35.2

Specific Gravity
Calculated: 0.586
Measured: 0.665

Pseudo Critical Properties
(Calculated)

PPC: 4565.94 kPa
PTC: 187.11 k

Mol. Wt. Total Gas: 17.98
C_7+: 0.00

APPENDIX VII - cont'd

WELL: SPC HUDSON BAY SUPREME 7-10-2-27
LOCATION: 7-10-2-27 W3
FORMATION: SECOND WHITE SPECKS
DEPTH INTERVAL: 835 - 868.7 Meter

Component	Mole %
H_2	0.00
He	0.25
N_2	5.81
CO_2	0.00
H_2S	0.00
C_1	93.33
C_2	0.42
C_3	0.09
IC_4	0.02
NC_4	0.03
IC_5	0.02
NC_5	0.02
C_6	0.01
C_7	Trace
C_8	0.00
C_9	0.00
C_{10}	0.00
TOTAL	100.00

Gross Heating Value MJ/M^3
(15°C and 101.325 kPa)

Calculated: 35.68

Specific Gravity
Calculated: 0.581
Measured: 0.586

Pseudo Critical Properties
(Calculated)

PPC: 4570.8 kPa
PTC: 187.72 k

Mol. Wt. Total Gas: 16.84
C_7+: 0.00

APPENDIX VII - cont'd

WELL: SPC NOTUKEU 11-6-5-27
LOCATION: 11-6-5-27 W3
FORMATION: SECOND WHITE SPECKS
DEPTH INTERVAL: 852 - 867 Meter

Component	Mole %
H_2	Trace
He	0.29
N_2	10.26
CO_2	0.12
H_2S	0.00
C_1	88.94
C_2	0.30
C_3	0.07
IC_4	0.01
NC_4	0.01
IC_5	Trace
NC_5	Trace
C_6	0.00
C_7	0.00
C_8	0.00
C_9	0.00
C_{10}	0.00
TOTAL	100.00

Gross Heating Value MJ/M^3
(15°C and 101.325 kPa)

Calculated: 33.84

Specific Gravity
Calculated: 0.599
Measured: 0.599

Pseudo Critical Properties
(Calculated)

PPC: 4517.53 kPa
PTC: 184.50 k

Mol. Wt. Total Gas: 17.34
C_7+: 0.00

APPENDIX VII - cont'd

WELL: SPC WEST PLAINS 10-7-5-27
LOCATION: LSD 10-7-5-27W3
FORMATION: SECOND WHITE SPECKS
DEPTH INTERVAL: 846 - 862 Meter

Component	Mole %
H_2	0.00
He	0.13
N_2	4.65
CO_2	0.10
H_2S	0.00
C_1	94.79
C_2	0.27
C_3	0.05
IC_4	0.01
NC_4	Trace
IC_5	0.00
NC_5	0.00
C_6	0.00
C_7	0.00
C_8	0.00
C_9	0.00
C_{10}	0.00
TOTAL	100.00

Gross Heating Value MJ/M^3
(15°C and 101.325 kPa)

Calculated: 36.01

Specific Gravity
Calculated: 0.575

Pseudo Critical Properties
(Calculated)

PPC: 4594.30 kPa
PTC: 188.00 k

APPENDIX VII - cont'd

WELL: SPC NOEL SENATE 11-12-2-28
LOCATION: 11-12-2-28W3
FORMATION: SECOND WHITE SPECKS
DEPTH INTERVAL: 807.7 - 824.5 Meter

Component	Mole %
H_2	0.00
He	0.12
N_2	28.52
CO_2	0.38
H_2S	0.00
C_1	70.26
C_2	0.29
C_3	0.06
IC_4	0.02
NC_4	0.01
IC_5	Trace
NC_5	0.01
C_6	0.14
C_7	0.17
C_8	0.02
C_9	0.00
C_{10}	0.00
TOTAL	100.00

Gross Heating Value MJ/M^3
(15°C and 101.325 kPa)

Calculated: 27.51

Specific Gravity
Calculated: 0.686
Measured: 0.687

Pseudo Critical Properties
(Calculated)

PPC: 4298.3 kPa
PTC: 174.05 k

Mol. Wt. Total Gas: 19.878
C_7+: 97.943

APPENDIX VII – cont'd

WELL: SPC SENATE 11-24-2-28
LOCATION: LSD 11-24-2-28W3
FORMATION: SECOND WHITE SPECKS
DEPTH INTERVAL: 810 - 825 Meter

Component	Mole %
H_2	0.00
He	0.27
N_2	7.96
CO_2	0.02
H_2S	0.00
C_1	90.70
C_2	0.34
C_3	0.08
IC_4	0.02
NC_4	0.01
IC_5	Trace
NC_5	Trace
C_6	0.04
C_7	0.06
C_8	0.13
C_9	0.19
C_{10}	0.18
TOTAL	100.00

Gross Heating Value MJ/M^3
(15°C and 101.325 kPa)

Calculated: 36.05

Specific Gravity
Calculated: 0.611
Measured: 0.611

Pseudo Critical Properties
(Calculated)

PPC: 4517.0 kPa
PTC: 188.4 k

Mol. Wt. Total Gas: 17.7
C_7+: 126.5

APPENDIX VII - cont'd

WELL: SPC SENATE 10-3-4-28
LOCATION: 10-3-4-28W3
FORMATION: SECOND WHITE SPECKS
DEPTH INTERVAL: 835 - 859.5 Meter

Component	Mole %
H_2	0.00
He	0.34
N_2	5.91
CO_2	0.17
H_2S	0.00
C_1	93.19
C_2	0.31
C_3	0.06
IC_4	0.01
NC_4	0.01
IC_5	Trace
NC_5	Trace
C_6	0.00
C_7	0.00
C_8	0.00
C_9	0.00
C_{10}	0.00
TOTAL	100.00

Gross Heating Value MJ/M^3
(15°C and 101.325 kPa)

Calculated: 35.45

Specific Gravity
Calculated: 0.581
Measured: 0.584

Pseudo Critical Properties
(Calculated)

PPC: 4571.5 kPa
PTC: 187.27 k

APPENDIX VII - cont'd

WELL: SPC AMOCO SEDAE 7-15-4-28
LOCATION: 7-15-4-28W3
FORMATION: SECOND WHITE SPECKS
DEPTH INTERVAL: 847.3 - 884 Meter

Component	Mole %
H_2	0.00
H_e	0.17
N_2	5.97
CO_2	0.07
H_2S	0.00
C_1	93.45
C_2	0.30
C_3	0.03
IC_4	0.01
NC_4	0.00
IC_5	0.00
C_6	0.00
C_7	0.00
C_8	0.00
C_9	0.00
C_{10}	0.00
TOTAL	100.00

Gross Heating Value MJ/M^3
(15 C and 101.325 kPa)

Calculated: 35.50

Specific Gravity
Calculated: 0.580
Measured: 0.583

Pseudo Critical Properties
(Calculated)

PPC: 4575.6 kPa
PTC. 187.38 k

Mol. Wt. Total Gas: 16.81
C_7+: 0.00

APPENDIX VII - cont'd

WELL: SPC MERRY FLAT 10-15-6-28
LOCATION: 10-15-6-28 W3
FORMATION: SECOND WHITE SPECKS
DEPTH INTERVAL: 937.5 - 951 Meter

Component	Mole %
H_2	0.00
He	0.20
N_2	7.75
CO_2	0.03
H_2S	0.00
C_1	92.02
C_2	0.00
C_3	0.00
IC_4	0.00
NC_4	0.00
IC_5	0.00
NC_5	0.00
C_6	0.00
C_7	0.00
C_8	0.00
C_9	0.00
C_{10}	0.00
TOTAL	100.00

Gross Heating Value MJ/M^3
(15°C and 101.325 kPa)

Calculated: 34.70

Specific Gravity
Calculated: 0.585

Pseudo Critical Properties
(Calculated)

PPC: 4550.00 kPa
PTC: 185.66 k

Mol. Wt. Total Gas: 16.96
C_7+: 0.00

APPENDIX VII - cont'd

WELL: SPC MERRYFLAT 7-19-6-28
LOCATION: LSD 7-19-6-28W3
FORMATION: SECOND WHITE SPECKS
DEPTH INTERVAL: 960 - 992 Meter

Component	Mole %
H_2	0.02
He	0.12
N_2	6.21
CO_2	0.00
H_2S	0.00
C_1	93.26
C_2	0.31
C_3	0.06
IC_4	0.02
NC_4	Trace
IC_5	0.00
NC_5	0.00
C_6	0.00
C_7	0.00
C_8	0.00
C_9	0.00
C_{10}	0.00
TOTAL	100.00

Gross Heating Value MJ/M^3
(15°C and 101.325 kPa)

Calculated: 35.45

Specific Gravity
Calculated: 0.581

Pseudo Critical Properties
(Calculated)

PPC: 4572.16 kPa
PTC: 186.94 k

APPENDIX VII - cont'd

WELL: SPC ET AL SENATE 7-12-3-29
LOCATION: LSD 7-12-3-29W3
FORMATION: SECOND WHITE SPECKS
DEPTH INTERVAL: 780.3 - 804.7 Meter

Component	Mole %
H_2	0.00
He	0.14
N_2	5.57
CO_2	0.00
H_2S	0.00
C_1	93.64
C_2	0.49
C_3	0.15
C_4	0.01
C_5	Trace
C_6	Trace
C_7	0.00
C_8	0.00
C_9	0.00
C_{10}	0.00
TOTAL	100.00

Gross Heating Value MJ/M^3
(15°C and 101.325 kPa)

Calculated: 35.78

Specific Gravity
Calculated: 0.580

Pseudo Critical Properties
(Calculated)

PPC: 4580.5 kPa
PTC: 188.22 k

APPENDIX VIII

Results of Drill Stem Tests in Upper Colorado strata of southwestern Saskatchewan.

APPENDIX VIII

Results of Drill Stem Tests in Upper Colorado strata of southwestern Saskatchewan

WELL NAME	LOCATION	KB (m)	D.S.T. INTERVAL (m)	REMARKS	STRATIGRAPHIC INTERVAL
UNGAS CAN-GEO ARENA 6-30-1-25	CTR 6-30-1-25W3	895.2	712-717	Gas Prod. 10 McF	Medicine Hat Sandstone
			834-839	Gas Prod. 312 Mcf	Phillips Sandstone
UBR AMOCO ROBSART 6-29-4-25	SE 6-29-4-25W3	951.6	920-927	Gas Prod. 70 Mcf	Phillips Sandstone
CDN RES DECALTA BATTLE CR 12-27-3-26	SW 12-27-3-26W3	963.8	866-892	Gas Prod. 108 Mcf, GTS	Phillips Sandstone
SPC AMOCO VIDORA 10-24-4-26	CTR 10-24-4-26W3	945.8	850-902	Gas Cut Mud	Phillips Sandstone
SPC VIDORA 7-25-4-26	CTR 7-25-4-26W3	952.5	860-882	Gas Prod. 80 Mcf, GTS	Phillips Sandstone
SPC ROBSART 7-16-5-26	CTR 7-16-5-26W3	965.6	850-875	Gas Prod. 30 Mcf, GTS	Phillips Sandstone
			867-875	Gas Prod. 14 Mcf, GTS	Phillips Sandstone
SPC SHELL MAPLE CREEK 6-21-9-26	CTR 6-21-9-26W3	947.3	655-716	Gas Prod. 6 Mcf, GTS	First White-Speckled Shale and Medicine Hat Sandstone
SPC SHELL MAPLE CREEK 7-6-10-26	CTR 7-6-10-26W3	884.8	604-665	Gas Prod. 9 Mcf, GTS	First White-Speckled Shale and Medicine Hat Sandstone
SPC WOOD PILE 11-15-1-27	11-15-1-27W3	892.5	677-710	Gas Prod. 6 Mcf, GTS	First White Speckled Shale and Medicine Hat Sandstone
SPC HUDSONS BAY SUPREME 7-10-2-27	7-10-2-27W3	940.3	835-869	Gas Prod. 2 Mcf, GTS	Greenhorn Lime and Phillips Sandstone
SPC SENATE 10-18-4-27	10-18-4-27W3	962.9	828-858	Gas Prod. 23 Mcf, GTS	Greenhorn Lime and Phillips Sandstone
SPC NOTUKEU 11-6-5-27	CTR 11-6-5-27W3	978.4	852-867	Gas Prod. 8 Mcf, GTS	Phillips Sandstone
SPC WEST PLAINS 10-7-5-27	10-7-5-27W3	973.2	846-863	Gas Prod. 14 Mcf, GTS	Greenhoen Lime and Phillips Sandstone

APPENDIX VIII - cont'd

WELL NAME	LOCATION	KB (m)	D.S.T. INTERVAL (m)	REMARKS	STRATIGRAPHIC INTERVAL
SPC WEST PLAINS 11-12-5-27	11-12-5-27W3	957.4	848-864	Gas Cut Mud	Greenhorn Lime and Phillips Sandstone
UBR AMOCO BATTLE CREEK 6-16-5-27	CTR 6-16-5-27S3	976.0	859-874	Gas Prod. 148 Mcf	Phillips Sandstone
SPC NOEL SENATE 11-12-2-28	CTR 11-12-2-28W3	920.8	808-825	Gas Prod. 71 Mcf	Greenhorn Lime and Phillips Sandstone
SPC SENATE 11-24-2-28	CTR 11-24-2-28W3	904.6	810-825	GTS	Greenhorn Lime and Phillips Sandstone
UBR NOEL SENATE 11-28-2-28	CTR 11-28-2-28W3	929.7	835-850	Gas Prod. 3991 Mcf	Phillips Sandstone
SPC AMOCO SENATE 7-4-3-28	7-4-3-28W3	930.0	805-814	Gas Prod. 382 Mcf	Phillips Sandstone
SPC SENATE 7-34-3-28	7-34-3-28W3	983.3	844-872	Gas Prod. 116 Mcf, GTS	Greenhorn Lime and Phillips Sandstone
SPC SENATE 10-3-4-28	SW 10-3-4-28W3	972.3	835-860	Gas Prod. 28 Mcf, GTS	Greenhorn Lime and Phillips Sandstone
SPC ET AL GOVENLOCK 10-6-4-28	CTR 10-6-4-28W3	973.8	829-853	Gas Prod. 26 Mcf	Greenhorn Lime and Phillips Sandstone
SPC POC AMOCO SENATE 7-15-4-28	CTR 7-15-4-28W3	982.4	847-884	Gas Prod. 28 Mcf, GTS	Greenhorn Lime and Phillips Sandstone
SPC SENATE 11-19-4-28	11-19-4-28W3	983.9	823-853	GTS	Greenhorn Lime and Phillips Sandstone
SPC MERRYFLAT 10-15-6-28	10-15-6-28W3	1069.9	938-951	GTS	Phillips Sandstone

APPENDIX VIII - cont'd.

WELL NAME	LOCATION	KB (m)	D.S.T. INTERVAL (m)	REMARKS	STRATIGRAPHIC INTERVAL
SPC MERRYFLAT 7-19-6-28	7-19-6-28W3	1117.1	960-992	Gas Prod. 1432 Mcf, GTS	Greenhorn Lime and Phillips Sandstone
SPC ET AL SENATE 7-12-3-29	CTR 7-13-3-29W3	939.1	780-805	Gas Prod. 3635 Mcf, GTS	Greenhorn Lime and Phillips Sandstone
SPC SIEBENS MERRYFLAT 7-20-6-29	CTR 7-20-6-29W3	1167.1	1000-1036	Gas Prod. 212 Mcf, GTS	Greenhorn Lime and Phillips Sandstone
SPC-NHP-ARCO CLEARSITE 7-21-9-29	7-21-9-29W3	1010.4	672-718	Gas Prod. 10 Mcf. GTS	First White-Speckled Shale and Medicine Hat Sandstone
			908-914	Gas Prod. 41 Mcf	Phillips Sandstone
SPC STEBENS MERRYFLAT 9-21-6-30	CTR 9-21-6-30W3	1172.0	994-1055	GTS	Greenhorn Lime and Phillips Sandstone
SPC STEBENS MERRYFLAT 7-26-6-30	7-26-6-30W3	1204.3	866-896	GTS	First White-Speckled Shale and Medicine Hat Sandstone
			1027-1058	Gas Prod. 317 Mcf, GTS	Greenhorn Lime and Phillips Sandstone

VITAE AUCTORIS

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